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The Mining Magazine

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EDITORIAL

WE promised to give in our January issue further information relating to Mr. Ernest Williams' detailed proposal in connection with his scheme for State mining in the Far East Rand. Owing to difficulties in connection with draughtsmanship, the preparation of the necessary illustrations has not proceeded smoothly, and Mr. Williams' article has therefore had to be postponed to our February issue.

IN our Mining Digest this month we give lengthy extracts from an article on the new Southern Nigerian coalfield that appeared in the last *Bulletin* of the Imperial Institute. The history of the discovery is described, the extent of the various outcrops is noted, and analyses of typical specimens are presented. The coal is of Tertiary age. Many of the seams are thin and others are too high in ash, but some of them are of great economic value. The seam at present worked in the Obweti valley is 5 ft. 8 in. in width. A sample taken 100 ft. from the surface along the adit averaged 54% fixed carbon, 34% volatile matter, and from 4 to $4\frac{1}{2}$% ash, with 0·5% sulphur content. This coal is used on the Government railways. When the railway from Port Harcourt to Naraguta is completed, the tin mines should greatly benefit, for their supply of fuel is notoriously short at present.

WHILE writing of Nigeria, we take the opportunity of observing that the Government officials representing the Colonial Office continue to be less helpful to the mining industry than we could wish. In particular the taxes and the railway rates are undoubtedly high, and the conditions generally compare unfavourably with those obtaining in the Federated Malay States. Mr. F. N. Best returned to the attack on officialdom at the meeting of the Naraguta company, of which he is chairman. His proposition is that a committee of business men and experienced administrators of the self-governing dominions should be formed for the purpose of advising the Colonial Office with regard to economic enactments in the Crown Colonies. This is a suggestion that merits friendly consideration.

JUDGMENTS in courts of law are not delivered in such a way that their details can be readily grasped. No doubt the bald announcement of a verdict for plaintiff or defendant is sufficient in most cases, but those who look for enlightenment from the bench as to the interpretation of arguments and assertions are often disappointed. For instance, the American press had to depend on an unofficial account of the Minerals Separation judgment, while this Magazine received an uncorrected, though official, shorthand report of the Globe & Phœnix judgment. In our case we were able to rectify many mistakes, for instance, altering "hinges" to "winzes," but we regret that we failed to alter "ore-sheet" to "ore-shoot," and let the word "defendants" pass where it should have been "plaintiffs." The judgments should be printed in type and corrected by the judge or his clerk before delivery in the court.

FOR too long have the mining papers and societies ignored the ore deposits containing non-ferrous metals found in the United Kingdom. News is published regularly from Cornwall, but how often do we hear anything of the lead and zinc mines in the North of England or in Wales? Everything possible must be done nowadays to develop the country's home resources, and to interest English capital in the production of metals within the confines of the kingdom. We are accordingly particularly gratified at being able to place before our readers this month the records of a specific example of what can be done in this line. Though the lead deposits of Weardale have been worked from time immemorial, they still afford excellent profits, and they supply he Munitions Department with lead and the steel-maker with fluor-spar. The results obtained by the Weardale Lead Company should serve to encourage other similar ventures. Professor Henry Louis has written for us a most readable account of the company's operations. His article is made additionally interesting by the historical outline of lead-mining in Weardale since the time of the Romans, while his notes on the galena "flats" constitute a useful addition to the literature of economic geology.

EVERY month, in our pages of statistics, we publish figures relating to the imports of metals, ores, and concentrates into this country. It is well to remark, in order that readers shall not come to wrong conclusions, that these returns do not include metals or ores which at the time of importation are the property of the British or the Allied Governments. Thus there is no mention of copper and zinc bought by the Government in America, while antimony is not mentioned at all. We have had it on our mind for several years to ask that more specific details should be given in these monthly Board of Trade returns; but the time is not now.

THE ambition of a man of public position is to die while at the zenith of his powers, or at any rate before his abilities have degenerated. The late Harry H. Marks failed to achieve this desire, and his death passes almost unnoted. His earlier sins found him out, and his unscrupulous methods of fostering share dealings in mining and other companies dulled his reputation as a financial critic. In spite of his many failings, and his disservice in representing mining as a mere counter in speculation instead of an honest industry, Marks was a personality who will not be forgotten. He founded the first daily financial paper, *The Financial News*, and infused human interest into the dry and eminently respectable bones of finance. By his attractive way of writing of investments and speculations, he made finance a popular science among people with money to place, and he caused the leaders of finance, the bankers, and the city merchants to feel ashamed of their long faces and of their terribly straight frame of mind. In later years his hold on the public began to fail, and the control and the editorship of the paper passed into other hands. But he was always a man of prodigious ability, though, like others we could mention, he failed to run on, shall we say, conventional lines, and thus he missed the opportunity of applying his great talents to the best interests of his country.

LAST month we published a précis of Mr. R. B. Watson's paper describing his use of sodium sulphide as a precipitant of silver from cyanide solutions. In commenting on the process we made reference to experiments with the same chemical by Messrs. Feldtmann, Marriott, and Wartenweiler in connection with gold metallurgy. During a fit of woolgathering, we wrote that sodium sulphide was used by these gentlemen as a precipitant of gold, whereas it is really used as a solvent. This error was entirely unjustifiable, seeing that Mr. Watson specifically says that his process is limited in its application to silver ores, as gold is not precipitated from cyanide solution in this way.

ONE of the political unrealities that have survived the recent revolution in Government methods is the rule forbidding the holding of directorships of public companies by Ministers of the Crown. The imposition of this unwritten law was, no doubt, originally prompted by the desire of the professional politician to keep the business man away from Westminster. It was also held up as a metaphorical banner denoting the purity of political life, for the Minister, divested of his directorships, was supposed to be unable to use for his private benefit knowledge acquired in the course of his public duties. Such a claim and attitude are in the nature of the hollow sham. An unscrupulous Minister could abuse his position just as well after resigning his directorates as he could if he had continued to hold them, for a directorate usually means the possession of a substantial interest or at any rate a "pull" in the company. In mining speculation in the city, does not the crafty director, when wishing to operate in the shares of his own company, resign from the board and appoint a nominee in his place ? The very fact that hiding of this kind is practised should teach politicians the futility of attempting to divest the dishonest holder of a ministerial post of his opportunities for self-aggrandisement. On the other hand it is in the nature of an insult to ask a man of public spirit and tried honour to protect himself from going wrong. In any case, whether the Minister is trustworthy or suspect, we should like his business connections to be publicly known, in the former case as an advertisement of his ability and integrity, and in the latter case as a precautionary measure.

TWO years ago we recorded that the South Australian Government had commissioned Mr. J. D. Connor to visit America with the object of studying the most recent practice in leaching oxidized copper ores, in order that information should be obtained that would be helpful in treating the deposits to the north-east of Spencer Gulf. Mr. Connor has written a report on his investigations, and copies are being distributed by the State Government. Though not containing any information that has not already been published, the report presents a useful summary of practice. In all probability other States in Australia will find the recommendations of value. For instance, the northern part of West Australia contains oxidized copper ores that are not being treated at a profit at present.

The Barnato-Randfontein Deal.

At a time when public attention in South Africa is devoted almost entirely to the discussion of the future development of the Far East Rand, Mr. S. B. Joel creates a sudden diversion of the current trend of thought by announcing the purchase by the Johannesburg Consolidated of Sir J. B. Robinson's interests in the Randfontein Estates and Randfontein Central, two companies operating on a big scale at the other end of the Witwatersrand goldfield. Control was secured at the same time of the Langlaagte Estates, but this deal is devoid of spectacular attraction. It is no further back than May 1916 when we wrote of the Randfontein Central output and finance, comparing the company with the two other consolidations, Crown Mines and East Rand Proprietary. During 1915 the ore treated was nearly $2\frac{1}{2}$ million tons and the output of gold £2,846,488, but costs, debenture requirements, and taxes practically swallowed the whole of this yield. From 1892 onward the fortunes of Randfontein have been verging on failure, whether the individual mines were worked by separate companies or under a combined administration. Sir J. B. Robinson was one of the early pioneers on the Rand, and indeed gave his name to the richest of all the producers, though he lost that property under circumstances that need not be recalled now. He was never a man that could meet another half way, and during the twenty or more years of Randfontein control, he failed to work amicably with his subordinates or with his equals. Instances of his aloofness are seen in his refusal to publish any details of the work at the mines or to throw in his lot with the other houses in connection with labour recruiting. Some time ago he placed debentures with the Central Mining group, and more recently there were unofficial rumours that he wanted to dispose of his shareholdings in the same quarter. The negotiations, however, came to nothing, no doubt owing to his disinclination to give full facilities for independent examination. That Mr. S. B. Joel has felt justified in accepting Sir Joseph's terms means either that such facilities have been granted or that he has received reliable indirect evidence of the value of the deposits.

The late Barney Barnato, the founder of the Johannesburg Consolidated, did not take as keen an interest in the gold mines as he did in diamonds, and the company did not get any of the early prizes of the Rand. Mr. S. B. Joel, though continuing to be a power in the diamond business, applied himself closely to the administration of gold-mining companies. During the last dozen years, with first Mr. J. Harry Johns and more recently Mr. J. G. Lawn as technical adviser, he has pushed the Johannesburg Consolidated to the front rank among the Rand controlling houses. He and his advisers have never indulged in experiments in the technology of mining and metallurgy, but have preferred to work energetically on well established lines.

In the field of mining and investment, however, the company undertook a notable experimental venture in connection with the Government Gold Mining Areas property at Modderfontein. Many people, including the rival houses, wondered that Johannesburg Consolidated should agree to terms so favourable to the Government and comparatively unfavourable to capital, but no doubt Mr. Joel won some offset advantage in connection with other deals with the Government, such as in the diamond properties. With regard to the Randfontein transaction, we can trust Mr. Joel's shrewd business ability, and we can look forward with some confidence to a change in the fortunes of the shareholders in that hitherto unlucky company.

The Return of Capital by Mining Companies.

Last month we referred to the endeavours of the controllers of mining companies to secure a less strangling application of the excess profits tax to their operations. Their argument rightly is that mining risks demand a comparatively large return on money invested, and that ample allowance should be made for the redemption of capital in the case of a wasting asset such as a mine. With regard to this redemption of capital, or amortization as it is nowadays called, we said that directors and shareholders have only themselves to thank for their present unenviable position, for very seldom have the companies applied profits for writing down the property account in the balance sheet. We promised that at another time we would say more on this point of amortization, so we return to the subject now.

In the first place we wish to say that this Magazine regards mining as an industrial business, the object of which is to extract serviceable metals and minerals from the ground in the most efficient way, and we desire to eliminate from all discussion the claims for consideration put forward by speculators who dabble on the Stock Exchange for a rise. Mining operations must be based on sound commercial foundations. The first elementary law to be remembered is that a profit is not made, either by the individual or by a company, until the original capital outlay is returned. As it is inconvenient for the individual to wait until this desirable event happens before obtaining some return, a system of accounting represented by the customary balance sheet and profit and loss account was devised, whereby the individual is enabled to receive a little on account of his expected profit. Thus the yearly balance of income over expenditure should be applied first to the provision of a sinking fund for the redemption of capital and secondly to the distribution of profit. The financier who takes care to secure a return of capital is the trustworthy man to follow. He understands that all assets in the balance sheet, whether it is a mine or a goodwill, should be represented by actual pounds shillings and pence, or by their realizable equivalent such as proved ore reserves, and that their value should not be merely nominal. The sooner the items in the capital account are changed into tangible security the better for everybody. These maxims are stale and trite no doubt, but how many mining companies follow them? It is true that some companies have accumulated reserve funds, but in these cases the object of the directors is not the return of capital to shareholders but to provide funds to carry on the organization after the exhaustion of the first property. The difference between accumulating a reserve fund and returning capital is that in the former case the amounts so placed are considered an allocation of profits and are therefore subject to income tax, whereas capital returned is not so assessed. A specific case of return of capital is provided by Mason & Barry Limited, the owner of the San Domingos copper-sulphur mine in Portugal. This company distributed £210,000 on four occasions as return of capital, in 1894, 1896, 1898 and 1900, on each occasion the shares, originally £5, being reduced by £1. The capital value of the wasting asset was more nearly represented by the reduced figures, and at the same time the shareholders enjoyed the advantage of not having to pay income tax on the £840,000 so distributed. The Mountain Copper Company Ltd., an English company operating in California, presents another example, though the machinery for effecting the return was different. On the orebody being found to be less extensive than originally expected, the bulk of the shares were converted into debentures, which were to be redeemed out of current profits.

The two cases quoted above are of historical interest, and represent methods of securing to current shareholders the benefits of a return of capital. A more recent example, that of the Kamunting Tin Dredging Company Limited, does not give this immediate benefit, nor does it relieve the profits applied to amortization from income tax or excess profits tax, according to the present ruling of the Inland Revenue authorities and of the Official Referees. The plan consists in taking out a thirty years' insurance policy for the return of the capital at the end of that period. The company treats alluvial tin deposits in the Federated Malay States, particulars of which, by the way, are given in Mr. Harry D. Griffiths' articles now appearing in the Magazine, and the value of the property is fairly accurately ascertained. The drawback of this plan, if it is a drawback, is that present shareholders do not receive any benefit, as the return will be at the disposal of the shareholders who happen to be on the register thirty years hence, either for distribution among themselves or to be used for further investment. Whatever the drawback may be to present shareholders, the plan will at any rate give something to the ultimate shareholders, an occurrence that does not so often happen under usual circumstances. Moreover the market for the shares will be steadied and the enterprise will thus be put on a commercial basis. Some critics have also said that the money placed with the insurance company could be more profitably employed if it was devoted to the construction of additional dredges. The money so spent would undoubtedly yield a bigger return than when it is merely receiving interest at deposit, and both the profits and return of capital would come at an earlier date. There is with each mining venture an ascertainable advantageous ratio of the maximum capital expended to the minimum time of return of capital. But it must be remembered that a universal pressing of production would have an adverse effect on the price obtained for the metal. Moreover, the increase of profits gained by pressing production would seriously affect the fortunes of the company, as most of the advantages would be absorbed by the excess profits tax.

There is still another point to be considered with regard to the amortization of capital. Most boards argue that this can be done better by each individual shareholder than by the companies. No doubt it is the duty of the individual to watch his own interests and to take care of his own funds. But is he as well able to judge of the life of a mine as the directors ? The latter have all facts before them all the time, and the shareholder does not enjoy the same advantage. This argument of the directors savours of special pleading, and makes us suspect that they have a secret desire to encourage exaggerated ideas of the profit-earning capacities of their companies. We therefore dismiss the individual responsibility theory, and maintain our contention that the companies themselves should attend to the amortization of their capital.

De-tinning Schemes.

The daily press throughout the Kingdom has been flooded during the last two months with announcements of a new scheme for utilizing the old tin cans that encumber the municipal dustbin. This scheme has been brought forward by Mr. Morgan L. Jones, who has formed a company called the British De-tinning Co., of Birmingham and Westminster, to carry his process into practice. He extensively circularized the mayors and corporations of the towns and urban districts, and invited them with their engineers to attend a conference held at Westminster on the 13th, 14th, and 15th of December. These local authorities, knowing little of the technology of tinplate and scrap metal, accepted Mr. Jones' invitation with alacrity, hoping to hear of some practicable proposal which would help them to exploit their collections of old tin cans to advantage. Many towns and boroughs had already provisionally agreed to provide ground and various facilities, imagining that the plans were ready for fruition. Those who attended the conference were, however, entirely disappointed, for Mr. Jones declined to give particulars as to the nature of his process and was unable to present any figures of cost. Indeed the disappointment was acute and in many quarters it assumed a hostile character. The conference ended in the appointment of a friendly committee whose duty was to investigate and make a report. We have no knowledge of the individuals who compose this committee or of their qualifications for judging of these matters. Seeing that Mr. Jones is wanting capital for his project, it would be advisable for him to approach the Treasury at once, and to submit his process and proposals to the experts who would be appointed by the authorities. We cannot afford in these days of stress to waste time and money on processes of unknown value. Proposals seeking public support should be quite clear and explicit, and opportunity should be afforded for competent criticism.

In default of any definite statement as to the nature of the process, we are obliged to glean what information or suggestion we can from such announcements as have been made. Mr. Jones commences by stating that if his process is adopted, never again will our old tin cans be sold to Germany to return in the form of cheap and attractive articles. From this we presume that Mr. Jones intends to clean and dismember the cans, and to employ the fragments in the manufacture of toys and similar oddments. It is difficult to believe that our old tin cans were ever shipped wholesale to Germany for this purpose, or that the general run of similar contents of German dustbins were ever utilized in this way. We know that the clean scrap of canning works provides the raw material for toy manufacture as opportunity offers, and that under certain circumstances packing tins and old enamelled sheets are used for this purpose, but it would surely never pay to recover the tinplate from all the tins, or to spend time in picking and choosing the tins that are suitable for this regeneration.

A circumstance making it difficult to judge of Mr. Jones' intentions is that he uses the word "de-tinning" in the name of his company. Redeeming the tinplate from old cans is not de-tinning. Furthermore, Mr. Jones says that he can treat old galvanized iron by his process, "spelter being a by-product." He may have some variation of the processes for treating the galvanized iron in an acid bath that does not attack the iron as well, but it would hardly be profitable to produce spelter, though it might be profitable to dispose of the product as a salt.

In the past many metallurgical chemists have attempted to regain tin from tinplate scrap, and the number of proposals has been extensive. In our issue of October 1914 we gave an outline of the present position of this industry. It is only natural that the canning companies should prefer to recover the tin from their scrap as metal instead of looking for an uncertain and unremunerative market among the makers of fancy goods. As for treating old tins for the recovery of metallic tin, the cleaning and the recovery of the solder adds to the cost, as does also the collection of the material and the sorting of it. The borough dust departments have usually been content to offer their accumulations to scrap iron dealers, but the price offered is so small that unless the towns are in the iron districts the deals do not go through. The only really successful treater of old tin cans has been Goldschmidt, of Essen. His idea was to compress the tins into blocks and treat them with gaseous chlorine. The result of this action is the production of tetrachloride of tin, a salt in demand among silk dyers, and commanding a good price. Goldschmidt erected works in Germany and France, and worked the process successfully. At about the same time the soda process was started at Limehouse by Mr. E. M. Cardos, who formed the London Electron Works Company to organize the collection and treatment of the refuse tins. His process produced tin oxide and this had to be sold to the tin smelters. Mr. Cardos found that his costs were against him, and he accepted Goldschmidt's proposition to continue the organization and substitute the chlorine process. Conditions were such that it was cheaper to compress the cans here and ship the blocks to Essen, where, after the removal of the tin, the material was delivered to the steel works. For further details of the Limehouse business, we may refer readers to our issue of October 1914, already mentioned. We doubt whether a chlorine process could be established here at present. For one thing a supply of chlorine would be next to imposible to obtain, for this element is applied for more pressing needs nowadays. Goldschmidt counted on cheap chlorine for the success of his process, and in the days before the war chlorine was almost a drug on the market, the producers having to seek all sorts of outlets. With the present price, five times the pre-war figure, de-tinning by chlorine would not be an attractive proposal. Moreover the market for tetrachloride is not brisk at present, owing to its chief application being among silk dyers.

We need not say any more, except to express our dislike of the mixture of secrecy and publicity which Mr. Jones gives us. It is advisable to make sure that we really can do as well as or better than Germany before saying too much about it.

Minerals Separation the Victor.

The Minerals Separation company won a signal victory in the United States last month when judgment was delivered in its favour by the Supreme Court at Washington. This judgment reversed that of the Circuit Court of Appeals, and restored the original judgment of the Montana Court. The action was taken against James M. Hyde in connection with the flotation process designed by him for the Butte & Superior company's zinc mines, the basis of the action being the claim that the Hyde process infringed the Sulman-Picard-Ballot United States patent 835,120, which corresponds to the British patent 7,803 of 1905. Flotation by oil and by gas was known before that date, but Sulman and Picard were the first to demonstrate that very small quantities of thin oil could be used, in conjunction with bubbles, for the purpose of floating sulphide particles. The patent in question definitely claims "a fraction of 1% of oil," and in practice this fraction is a small one, so much so that Theodore Hoover, in his book, feels justified in giving the amount as 0·1%. Minerals Separation's position is made all the stronger by the fact that all nine judges agreed. For full details of the judgment we must refer readers to the report given in the *Mining and Scientific Press*, but briefly we may say that the success of the Minerals Separation process, without push or advertisement, carried conviction among the judges as to its novelty as compared with anything introduced previously. The company has recently won another case in America, obtaining judgment against the Miami Copper company in connection with the Callow flotation process. This judgment was given in the Delaware Court of first instance, and, in view of the decision of the Supreme Court in the Hyde case, an appeal can hardly be considered as affording promising possibilities. The Sulman-Picard-Ballot patent came out top in the Australian and English litigation, when Minerals Separation appeared as defendants, and it has now won in the United States in the character of plaintiff. As far as the company is concerned, its own litigation is at an end, but in flotation questions there is always the chance of some other party being desirous of taking a long shot. Apart from this chance, the position of Minerals Separation in the United States appears to be that the mining companies have to decide whether to increase, legitimately or otherwise, their oil consumption to over ·1% or to gracefully pay the royalties, while on the other hand Minerals Separation will have to fix its royalties on such a scale that the mining companies will not feel tempted to dodge that percentage. Even with this low royalty, the total income of the Minerals Separation company will be large. For instance, during 1916 about 11,850,000 tons of ore has been treated by licensees, among whom the Anaconda and Inspiration may be mentioned, and the royalties will amount to £140,000. During the same time the infringers, of whom the Jackling group were the chief, treated 13,500,000 tons, and this should yield a royalty of £160,000, if calculated at the same rate. The infringers will have to give an account of their profits earned since they commenced the operation of their flotation plants about three years ago. According to United States law, Minerals Separation is entitled to the whole of the profits so made, which are estimated at about £5,000,000. It would not be politic for the directors of Minerals Separation to exact their pound of flesh; but the infringers will see the justice of paying a good deal more than the ordinary royalty. They took a gambler's chance and must pay their debts of honour. Minerals Separation will reap still another advantage from the settlement of the patent position, because a great number of mine owners, who hesitated on account of the uncertainty, will now embark on a flotation campaign. In order to cope adequately with the increasing business, a new company, called the Minerals Separation North American Corporation, has been formed, with its domicile in America.

At the risk of wearying some of our readers, we take this opportunity of recapitulating the strenuous history of Minerals Separation. In the year 1902, Messrs. Ballot, Hay, and Webster approached the Elmores with the object of securing the Australian rights of the earlier Elmore bulk-oil flotation process. The deal was not consummated, and Mr. Ballot and his friends turned their attention to the work of inventors who had introduced other methods of applying oil for flotation, at dates later than the Elmore bulk-oil patents of 1898 and 1901. They formed the Minerals Separation company at the end of 1903, and acquired the Cattermole, Sulman & Picard, and Froment patents. These patents disclosed the use, in various ways, of small proportions of oil in conjunction with buoyant bubbles, though the earlier Cattermole patents were intended for the agglomeration of fine sulphide particles and the sinking of the granules. Continuation of research and experiment by Sulman & Picard led to the definite proof in 1905 that a fraction of 1% of oil could be employed. Subsequent research and experiment by many engineers and chemists, among whom may be mentioned Messrs. T. J. Hoover, G. A. Chapman, A. H. Higgins, Henry Lavers, H. H. Greenway, and James Hebbard, extended the range of possible oils and improved the mechanical methods employed. At the present time the process is so economical to work that the total operating cost of a concentration plant at a big mine is no higher than it was before the installation of the flotation section, so that the whole of the additional concentrate extracted by this means represents so much profit.

The company started its large-scale experimental work at the Central mine of the Sulphide Corporation, Broken Hill, in the year 1905, and in 1907 commenced the treatment of zinc tailing from the mill. In the latter year also the company erected a plant to trea the old tailing heaps. In the meantime the Zinc Corporation had been formed by Messrs. Bewick, Moreing & Co., of which firm Mr. H. C. Hoover was then a partner, for the purpose of treating other dumps at Broken Hill. The early experiments with the Minerals Separation as conducted by the Zinc Corporation did not give sufficiently good results, and Elmore vacuum plant was substituted. In 1911, however, the improved Minerals Separation plant was erected and the Elmore plant abandoned. The recent development of the process along the lines of preferential flotation has been an important feature, as this modification makes it possible to treat the slime in such a way that lead is first raised without the zinc. In this connection the names of the inventors Messrs. E. J. Horwood, T. M. Owen, and F. J. Lyster deserve mention.

The company had much litigation to face in England and Australia. The English patents were held to be good by the House of Lords. The action tried in Australia, though brought against the Sulphide Corporation, was aimed at the Minerals Separation company. This case ended in favour of Minerals Separation, both in the Australian courts and before the Judicial Committee of the Privy Council. Other actions in Australia were those brought by the company against the owners of the De Bavay patents, and by the owners of the Potter patent of 1902 against the Sulphide Corporation. When the De Bavay company bought the Potter interests, it became obvious that these two suits were evenly balanced, so that an amicable agreement was made in 1912 between the De Bavay company and Minerals Separation. By this agreement the royalties in Australia were pooled, and Minerals Separation acquired the Potter and De Bavay patent rights in other countries. We may suitably conclude our remarks by mentioning that seldom, if ever, has a company come successfully through such a series of law-suits, and that, though other inventors deserve a large proportion of credit for their services in developing the flotation idea, the eventual victor in the courts of law is also the victor in the practical application of the principle.

REVIEW OF MINING

Introductory.—The war and European political conditions have monopolized attention during the past month. The formation of a British Government with an energetic man at the head, and containing many experienced business men, has been received with universal gratification within the Empire and among our Allies. The false peace proposals of the enemy have served to enlighten the world with regard to the internal condition of Germany and its associates. Coming to subjects, more closely related to mining, we observe with satisfaction that the unnatural inflation of the so-called copper quotation has been reduced to some extent, and that it is not now at the prodigiously high level of a month or more ago. This is one of the wholesome effects of the Government taking control of copper in this country. The victory of Mineral Separation in the United States continues to afford pleasure in this country, in that British genius for invention is officially recognized in America. The announcement of the discovery of extensive deposits of "porphyry copper" in Siberia has greatly pleased the shareholders in the Irtysh Corporation. Developments at Dolcoath have been favourable lately, and details are anxiously awaited. The St. John del Rey is to sink to 7,000 ft. vertically below outcrop.

Transvaal.—The figures for the output of gold on the Rand and in other districts of the Transvaal, during December, and for the year 1916, had not arrived at the time we went to press. The reports relating to native labour at the gold mines, diamond mines, and coal mines are also wanting. The probability is that the gold output of the Transvaal during 1916 will be slightly higher than that for 1915. Details of the investigation into the possibilities of State mining in the Far East Rand are given by our Johannesburg correspondent. In our editorial columns we refer to the purchase of control in Randfontein Central by the Johannesburg Consolidated.

The dividends declared on the Rand during 1916 totalled £7,093,352, as compared with £7,620,064 in 1915, and £8,070,659 in 1914. Kleinfontein, Langlaagte, East Rand Proprietary, and Durban Roodepoort Deep paid nothing for the second half of the year. Glencairn, May Consolidated, and West Rand Central have dropped out. Of the 39 companies paying dividends, Jupiter is the only new one. Increased dividends were paid by Modder Deep, Modder B, Van Ryn Deep, Brakpan, and City Deep.

The East Rand Proprietary Mines has arrived at the non-dividend-paying stage. About four years ago the fact that the development and stoping were giving ore of lower grade than the original estimate became recognized, and the profits have gradually fallen since. In our issue of May last we gave an outline of the position, showing that the reserve was sufficient for only two years, and that the current development was disappointing. The company now announces that no dividend will be distributed for the second half of 1916. An interim dividend of 2½% was paid in June last. For 1915 the dividend was 11¼%, for 1914 17½%, for 1912 and 1913 25%, for 1911 30%, and for 1909 and 1910, the years subsequent to the consolidation, 40%. The directors state that the funds are kept in hand partly for the benefit of the debenture debt, and partly to provide capital for further underground work.

The New Kleinfontein company is not paying a dividend for the second half of 1916, owing to capital requirements for the new plant for the Apex section. It will be remembered that in 1914 the company absorbed the Benoni and Apex properties, and that the financing of the new plant and of the development falls on the revenue. Labour conditions have not been satisfactory during the last half of 1916, and the Apex mill, having a capacity of 25,000 tons per month, is not yet fully employed.

Another company that is not paying a dividend for the second half of 1916 is the Durban Roodepoort Deep, the profits being required to pay for two underground winding plants. The Bantjes company pays no dividend for 1916, as the operations have resulted in a loss.

The directors of Modderfontein B announce that additional plant is to be erected, and that the monthly capacity will thereby be raised from 45,000 to 60,000 tons. As we recorded in our issue of May last, the whole of the western section has been proved to contain ore of satisfactory grade, and an expansion of the scale of operations was then indicated. The cable message announces that practically all the new plant is obtainable in South Africa and that its erection should be completed in nine months.

The Sheba company, operating at Barberton, is once more at a critical stage of its existence. During its thirty years life there have been many variations in its fortunes. In the middle nineties large sums were distributed as dividends, but as the nominal capital was high, and the Stock Exchange quotation a good deal above par, the returns on money invested were inconsiderable. After a series of unsatisfactory years, a drastic reduction of capital in 1911, followed by a concentration of efforts on a few of the many properties, brought back a certain amount of prosperity. But during the past year the developments have been poor and the grade of the reserves has fallen seriously. At the Zwartzkopje, the best of the properties recently, the outlook is particularly discouraging, and none of the other mines appear to give any promise of taking its place.

Rhodesia.—The output of gold during November was worth £317,135, as compared with £325,608 in October and £313,160 in November a year ago. At Globe & Phœnix the yield per ton has been higher the last two months; in November 6,263 tons yielded £39,975, or 127s. 8d. per ton, at a working profit of 80s. per ton. The yield per ton at Lonely Reef has also increased, the figure for November being 76s. 9d. as compared with 53s. in July.

Pleas for indulgent treatment under the excess profits tax are being heard piecemeal, as urged by groups of mining companies operating in various countries. Rhodesian gold mining is the latest to receive relief. In this case the individual will be allowed to make 23½% and companies 22½% before the profits come within the scope of the tax. It is not likely that any companies will come within the scope of this tax, unless Globe & Phœnix continues its recent advance in profits.

The mysterious agitation against the board of the Amalgamated Properties of Rhodesia, on the part of certain Scottish shareholders, still continues. Early this month a meeting of shareholders was convened by these agitators, but the sense of the meeting was quite against them. Before Mr. Justice Eve's judgment in the company's action against the Globe & Phœnix was given, this agitation was chiefly secret and personal. Since then, the attack has been more open, and the board is blamed for embarking in rash ligitation. This accusation is entirely unwarranted, for the board was backed by excellent legal and geological advice. The fact that the company lost its case in the court of first instance is no reflection on the capacity of the board.

The Bwana M'Kubwa copper mine was reopened in April last, and concentration of oxidized ore of over 10% has been proceeding since. The concentrate produced averages 40% copper. Under normal conditions the capacity of the plant is 200 tons of concentrate per month, and at this rate the reserve is sufficient for a year. To treat the lower grade ore averaging 4 to 5%, of which there is 3 million tons above the 350 ft. level, an electrolytic leaching process has been adopted, which is estimated to yield a profit of 10s. per ton of ore. It is intended to start with a plant having a capacity of 100 tons per day, and to extend it gradually to 500 tons. The difficulty has been to place the order for the plant in this country. The tenders from America are so much higher than originally estimated that the company's capital resources are insufficient. Negotiations are pending among leading shareholders for raising further funds.

The Rhodesia Broken Hill Company reports that the blast-furnace parts and the power plant have arrived in Africa. It is hoped that the first furnace will be ready to start toward the end of March and the second a month later. The combined capacity of the furnaces is 900 tons of lead per month. The method of treating the oxidized zincy lead ore was devised by Mr. S. J. Speak on lines described in our issue of August last. In order to conduct operations, capitalists came forward with a proposition to form a company called the Rhodesia Lead and Zinc Syndicate, which is leasing the property from the Rhodesia Broken Hill company for five years. This syndicate has a cash capital of £10,000, and has issued £60,000 5% debentures at 83½%; it holds an option on 120,000 shares in the Rhodesia Broken Hill at par. When the syndicate has received its capital back plus £20,000, the lease is automatically cancelled.

West Africa.—The output of gold during November was worth £130,101, as compared with £132,577 in October, and £122,138 in November a year ago. The total for the eleven months of the year was £1,468,897, a fall of £79,253 as compared with the corresponding period of 1915. Prestea Block A showed a considerable improvement over October, but the returns from Taquah and Abosso were rather less.

During the last few months the aggregate output of the tin producers in Nigeria has been advancing, the figures being 679 tons for November, 584 tons for October, 535 tons for September, and 498 tons for August. Mongu heads the list in November with 80 tons of tin concentrate, as compared with 50 tons in October, and 30 tons in September. Other companies that record increases are Ropp, Ex-Lands Nigeria, and Bisichi.

Australasia. — A few months ago record rains were experienced in parts of Victoria and New South Wales. This month news is to hand of exceptional downfalls in Central Queensland, and in particular the Clermont district has been a sufferer from floods.

The Mount Morgan company announces that during the six months ended November 26, 181,922 tons of ore was raised, of which 79,217 tons went to the dressing plant, producing 22,694 tons of concentrate. At the smelter, 99,209 tons of ore and 19,771 tons of concentrate were treated, together with 32,622 tons of Many Peaks fluxing ore. The yield of copper was 4,554 tons, and of gold 54,746 oz. The net profit was £141,515, out of which £100,000 has been paid as dividend, being 10% for the half-year. With the exception of small amounts required locally, the output of refined copper for 1917 has been sold to the Ministry of Munitions at a price equal to £120 per ton c.i.f. London.

The Broken Hill Proprietary has issued the remainder of its debentures, £400,000, bringing the total issue to £1,000,000. The success of the iron and steel industry has been rapid, and many extensions are contemplated. The Treasury did not give permission for the offering of these debentures in England, and presumably most of them were placed through the Commonwealth Bank.

The Mount Lyell company continues to experiment with methods for producing elemental sulphur from pyrite prior to smelting. This is done in closed retorts or in reverberatories from which air is excluded. The closed retorts are heated externally by electric current, and it is believed that the cost of electricity is sufficiently low to make the process feasible. Recently we recorded that the Lake Margaret hydro-electric station was to be increased in capacity from 5,000 h.p. to 6,200 h.p. It has been decided since to increase it further, to 10,000 h.p. The heightening of the dam and the erection of additional plant will cost £60,000.

Last month we congratulated Lord Harris on the completion of 21 years as chairman of the Consolidated Gold Fields. This month a similarly pleasant record can be mentioned in connection with the Earl of Kintore, who has been chairman of the Sulphide Corporation continuously since its start in 1895. The report submitted at the shareholders' meeting held on December 21 showed by far the biggest gross profit yet made, the figure being £771,308. During the life of the company, £2,000,000 has been distributed as dividends. The company, besides operating the Central mine at Broken Hill, has a lead smelter at Cockle Creek, New South Wales, and a zinc smelter at Seaton Carew in the north of England; and at Cockle Creek also produces sulphuric acid, superphosphate, sulphate of ammonia, and tar products. The company is distinguished as having been the godfather of the Minerals Separation process. We give a short résumé of the report in our Mining Digest, and extracts from the Chairman's speech in our advertising pages; both report and speech are, however, well worth perusal in full. The Chairman had a good deal to say about the high taxation to which the company is subjected. With State, Federal, and English taxes, more than half the profit is absorbed.

Developments at the Yuanmi gold mine have proved the lode to continue in depth. Ore has been disclosed on the 5th and 6th levels and in winzes below the latter. It is intended to sink the shaft and open a 7th level. During the last financial year, treatment of 33,821 tons of ore yielded bullion worth £75,696, and after writing off for depreciation of plant, a loss of £6,247 was incurred. The reserve of ore is estimated at 51,308 tons averaging 50s. per ton, an increase of 5,746 tons and 9s. per ton as compared with the figures a year ago. The Warriedar option has been abandoned, as the ore did not come up to expectations; £14,755 has been written off for money spent on this option.

Recently the Tumut-Kiandra district, in the south of New South Wales, was the scene of a great landslip, and a fissure 60 ft. wide was left. It was commonly reported that natural gas was coming from this fissure. This rumour has not been substantiated. Mr. J. B. Jaquet, Chief Inspector of Mines, has, however, shown that methane gas is issuing into the workings of copper mines close by. He recommends prospecting in depth by diamond drill in order to seek for the origin of this gas, and incidentally to prospect the copper lodes.

The Malayan Tin Corporation is an Australian company, with its headquarters at Sydney, that is spreading its interests in many countries. Lode and placer properties containing gold and platinum have recently been secured in Siberia. Attention is also being turned to New Zealand, and a placer property at Kurama is being sampled.

Cornwall.— The year which has just closed, in spite of war conditions, has not been without its encouraging features for those who have confidence in the future of Cornish mining. The development of a great body of high-grade ore at East Pool & Agar, the improvement of Basset in the deepest levels, the recent discovery at Dolcoath which raises hope for an improved state of affairs at this famous old mine, the settlement of the long-outstanding differences with the mineral owners respecting a new lease at Levant, the formation of the Cornish Chamber of Mines, the appointment of a committee for research work in the treatment and recovery of tin and wolfram ores with a grant from the Privy Council, and finally the growing realization by those in authority of the possibilities of the West of England as a field for mining enterprise, have all been matters of satisfaction to the small band of Cornishmen and others, who believe that the day will come, and at no distant date, when the industry will command the financial support which past records show it is worthy of receiving.

The London Tin Smelting Co., controlled by Henry R. Merton & Co., has hitherto treated the ores purchased at Northfleet near Gravesend. The company is now erecting works near Falmouth, so in the near future its activities will be increased.

Canada.—The search for molybdenite has been greatly stimulated by the demand for this mineral for war purposes. Deposits occur near Quyon, in Quebec province, where there has been a rush to stake out claims. One mine, owned by the Canadian Woods Molybdenite Co., has begun mining operations. Many of the other claims are being tested with a view to development, and a permanent industry will probably be established.

At Kenabeek, a station on the Charlton spur of the Timiskaming and Northern Ontario railway, a property owned by the Kenabeek Mining Co. has been under development for about a year. A vein 18 in. wide, carrying high silver contents, was recently found at a depth of 63 ft. and there are other promising showings. The mine appears likely to be a steady producer.

The 4-weekly statement of the Hollinger Consolidated at Porcupine for the period ended November 3 shows gross profits of

$241,591 from the treatment of 49,956 tons of ore, of the average value of $8·62 per ton, at a working cost of $3·64 per ton milled. The deficit due to the increased dividends payable since the merger was $238,148. According to the terms of the amalgamation there is a liability of $720,000 to the shareholders of the Acme, Millerton, and Canadian Mining & Finance companies. This will be cancelled by an issue of 120,000 shares of treasury stock, which is offered to shareholders at $6·50 per share. The proceeds, in addition to paying off the debt, will help to wipe out the deficit. The new mill buildings, the construction of which has been delayed by the shortage of labour, are now nearly completed, and the installation of machinery will shortly be commenced. The addition is expected to be in running order by June next, when the present production of 1,900 tons per day should be nearly doubled.

United States.—The inflow of gold into the United States, delivered for the purpose of steadying the credits of Great Britain and the Allies, is enormous, and is causing perturbation among American economists. During the week ended December 20, no less than $27,000,000 was deposited in New York and Philadelphia. From January 1 to that date, the total influx was $608,500,000. From the beginning of the war, the imports have been $1,100,000,000, and the exports $275,000,000, leaving net imports of over $800,000,000. The gold stocks throughout the world on January 1, 1916, were $2,441,000,000, distributed as follows: United States $2,230,000,000, France $1,384,000,000, Russia $1,058,000,000, Germany $714,000,000 United Kingdom $662,000,000, Italy $336,000,000, Austria-Hungary $296,000,000, Turkey $291,000,000, Australia $250,000,000, Argentina $229,000,000, Netherlands $173,000,000, Canada $170,000,000, Spain $167,000,000, and Japan $143,000,000.

Mexico.—Recent developments at the Santa Gertrudis silver mine, Pachuca, have revealed no ore in the bottom levels. The internal, or counter, shaft, started from the 19th level, has been continued, and a 22nd level opened. Driving on this level has revealed no ore so far. On the other hand, exploration in the intermediate lode and search for ore in the hanging wall of the main lode have met with success, so that the ore reserve has not been seriously depleted.

Russia.—Last month we recorded recent progress at the Ridder lead-zinc-silver mine, the Ekibastus coal mine, and the lead and zinc smelters, belonging to the Irtysh Corporation. At the meeting of shareholders held subsequently, Mr. Leslie Urquhart, the chairman, made a further announcement. Not very far from the coal mine an extensive deposit of disseminated copper ore has been discovered. This has the appearance of the deposits in Utah and Arizona, and the manner of developing it will probably be the same. The handling of this property will have to be done by a subsidiary, but a start can hardly be made at present.

Brazil.—In our last issue we briefly recorded that horizons 19 and 20 at the Morro Velho mine of the St. John del Rey company had been proved to contain ore of equal extent and content to that found in the horizons above, where the recovery value averages from 44 to 49s. per ton. These horizons are respectively 5,526 ft. and 5,826 ft. vertically below the outcrop. The favourable result on horizon 20 has caused the directors to decide to sink 1,200 ft. deeper, the sinking to be done from an "H" internal shaft starting from the opposite end of horizon 20 to the "G" shaft. This depth will provide for the opening of 21st, 22nd, 23rd, and 24th levels, the last to be 7,026 ft. vertically below outcrop. Orders for the necessary power and hoisting plant, and for the ventilating plant, have already been given. Mr. George Chalmers, the manager, has closely studied the conditions with regard to the heat of the rocks for some years, and has ascertained the possibilities of reducing the temperature of the workings by means of ventilation. His plans in this direction were prepared some time ago, and he was only waiting the results of development at the 20th horizon before he made a start. We gave some quotations from his reports on temperatures at depth in our issues of July 1911 and July 1912. The Morro Velho is already the deepest gold mine in the world, and it promises to far out-distance any possible rival.

LEAD MINES IN WEARDALE, COUNTY DURHAM,

WORKED BY THE

WEARDALE LEAD COMPANY, LIMITED.

By HENRY LOUIS

M.A., D.Sc, A.R.S.M., F.I.C., F.G.S., M.Inst.C.E., etc.
Professor of Mining in Armstrong College, University of Durham.

THE scene of the operations of the Weardale Lead Company Limited is the extreme western end of the County of Durham (see Fig. 1), lying on the eastern slopes of the Great Pennine chain of hills, and comprises the valleys watered by the upper reaches of the river Wear and several of its tributaries. The lower portions of the Wear valley are well wooded and picturesque, but the upper portions consist of vast undulating expanses of heather-covered uplands, possessing to the full the wild charm always associated with British moorland scenery, beloved of the sportsman ; it should be added that some of the best of grouse-shooting is to be had on these desolate "Fells," a word which, by the way, like so many others in the vocabulary of the sturdy dalesman, is reminiscent of the Scandinavian strain in his ancestry. The area held by the Weardale Lead Company is some 85 square miles, as shown by the map on the next page, Fig. 2 ; it extends from the little town of Stanhope, the capital of Weardale, to the borders of Cumberland, and is roughly triangular in shape, owing to the way in which the County of Durham narrows westward.

Geologically the entire district consists of the Bernician Series, Carboniferous Limestone, or "Lead Measures." The general dip of the strata being northeasterly, a section from east to west, that is to say, from the

FIG. 1. MAP OF DURHAM AND ADJOINING COUNTIES, SHOWING THE POSITION OF THE WEARDALE LEAD MINES.

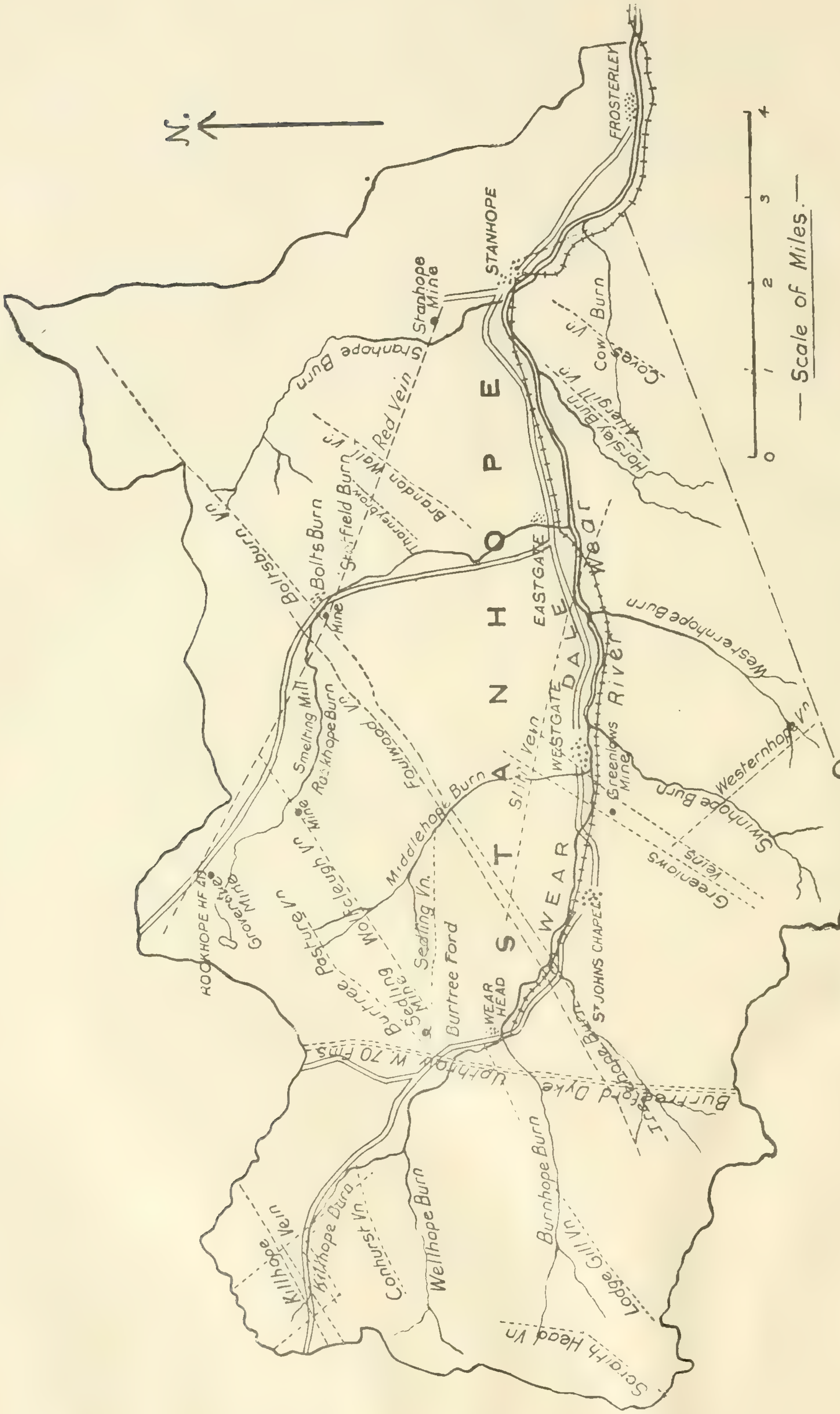


FIG. 2. MAP OF THE WEARDALE LEAD COMPANY'S AREA.

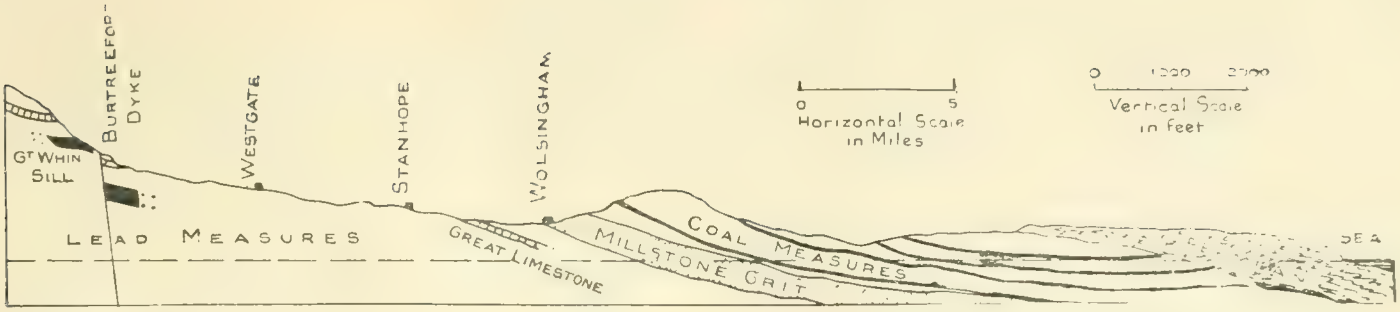


FIG. 3. DIAGRAMMATIC SECTION OF COUNTY DURHAM ALONG AN EAST-WEST LINE THROUGH WOLSINGHAM.

sea-coast to the axis of the Pennine Chain, as in Fig. 3, would show firstly the Magnesian Limestone lying unconformably upon the eastern edge of the Durham coalfield with its magnificent coal seams. From beneath the edges of the coalfield emerge the outcrops of the Millstone Grit and Ganister beds, some of which are quarried in the Weardale district, and from below these beds in turn emerge the rocks of the Bernician Limestone series; these latter are traversed by a complex series of fissure veins, carrying principally fluor-spar, spathic iron-ore, and galena. It is this great system of veins that has given rise to the lead-mining industry of Weardale, which has played so all-important a part in the history of this remote valley, from the earliest times of which we have any record down to the present day. The Bernician Series is about 2,500 feet thick, and consists of alternations of beds of Limestone, Sandstone, often spoken of locally as "Hazle," and Shale or "Plate." The general section of these strata, as developed in Weardale, is shown in Fig. 4. The rise of the strata to the westward is more rapid than that of the surface contours, considerable though the latter is; this is well seen by tracing the successive positions occupied by any particular bed of the series, such for instance as the well characterized and uniformly persistent bed known as the Great Limestone. This Limestone forms the bed of the river Wear at Frosterly, at about 530 ft. above sea-level; at Wearhead, about 12 miles farther up the river, the bed of the river is about 1,090 ft. above sea-level, whereas the Great Limestone has reached an elevation of nearly 2,000 ft. It is a well known characteristic of the veins traversing these strata that they are rarely productive in the shales, only occasionally workable when cutting through the sandstones, and far richest when the walls consist of limestone. Indeed records show that one single bed of the latter, the above-mentioned Great Limestone, has produced more lead than all the rest of the Ber-

nician Measures put together. Most of the veins of this district occupy fault fissures, the throw being only small as a rule; it would appear that both unfaulted fissures and fissures accompanied by considerable faulting present conditions unfavourable to the deposition of lead ore. The only really important fault is that known as the Great Burtreeford Dyke (the term dyke is frequently used locally as equivalent to fault), which traverses the property near its western end, and which has in places a throw of about 500 ft.; it is not mineralized. The only igneous intrusion of any importance in the district is the Great Whin Sill, which is, however, not a conspicuous feature in Weardale; its chief exposure is in Monkhouse's quarry on Killhope Burn, where it has been thrown up by the fault just mentioned. At this point the Sill forms a very thick mass or boss; it has been sunk through in two of the Weardale mines, Slitt and Burtreeford, and was found to be 240 ft. thick in the latter. A smaller sheet of intrusive basalt, the Little Whin Sill, never exceeding 30 ft. in thickness, is found outcropping at a few places in Weardale.

A few of the more important veins are shown on the map in Fig. 2, but it is impossible to show them all on so small a scale without confusion. The veins in this district belong to two main groups; one of these consists of a number of practically parallel veins, running about NE–SW, of which Reahope, Brandon or Greenlaws, Boltsburn, Rispey, Wolfcleugh, Burtree Pasture, and Killhope Head veins are the most important, having all yielded large quantities of lead ore. Another group of veins runs ESE–WNW, of which Slitt, Sedling, and Red veins are the most important; these veins only carry lead in places, but are strong masterly veins, and often carry important quantities of fluor-spar; thus in the Stanhopeburn mine the Red vein has been worked fully 26 ft. wide from wall to wall, the entire width being filled with clean massive fluor-spar. There are also a few veins, like Breckon Syke and Scraith Head veins, that run about NNE–SSW, but these are less important. The Weardale veins show as a rule but little dip; what little there is, is usually northward, and it is generally most marked in the portion of the veins traversing the plate beds; it is quite usual to find veins practically vertical where they traverse limestones and sandstones, but with marked dips where traversing shales.

A most important feature characteristic of the Weardale lead veins is the tendency shown by some of them, notably of the first group, to "flat." When the veins cut through limestone beds, horizontal flats, pockets, or bunches make off from the sides of the veins, often connected with the latter by narrow "leads"; they are really bunches or irregular masses of ore, that follow certain of the horizontal joints of the Limestone, and therefore have their greatest extension horizontally. Such flats may be 8 or 10 ft. deep, 40 or 50 ft. wide, and up to

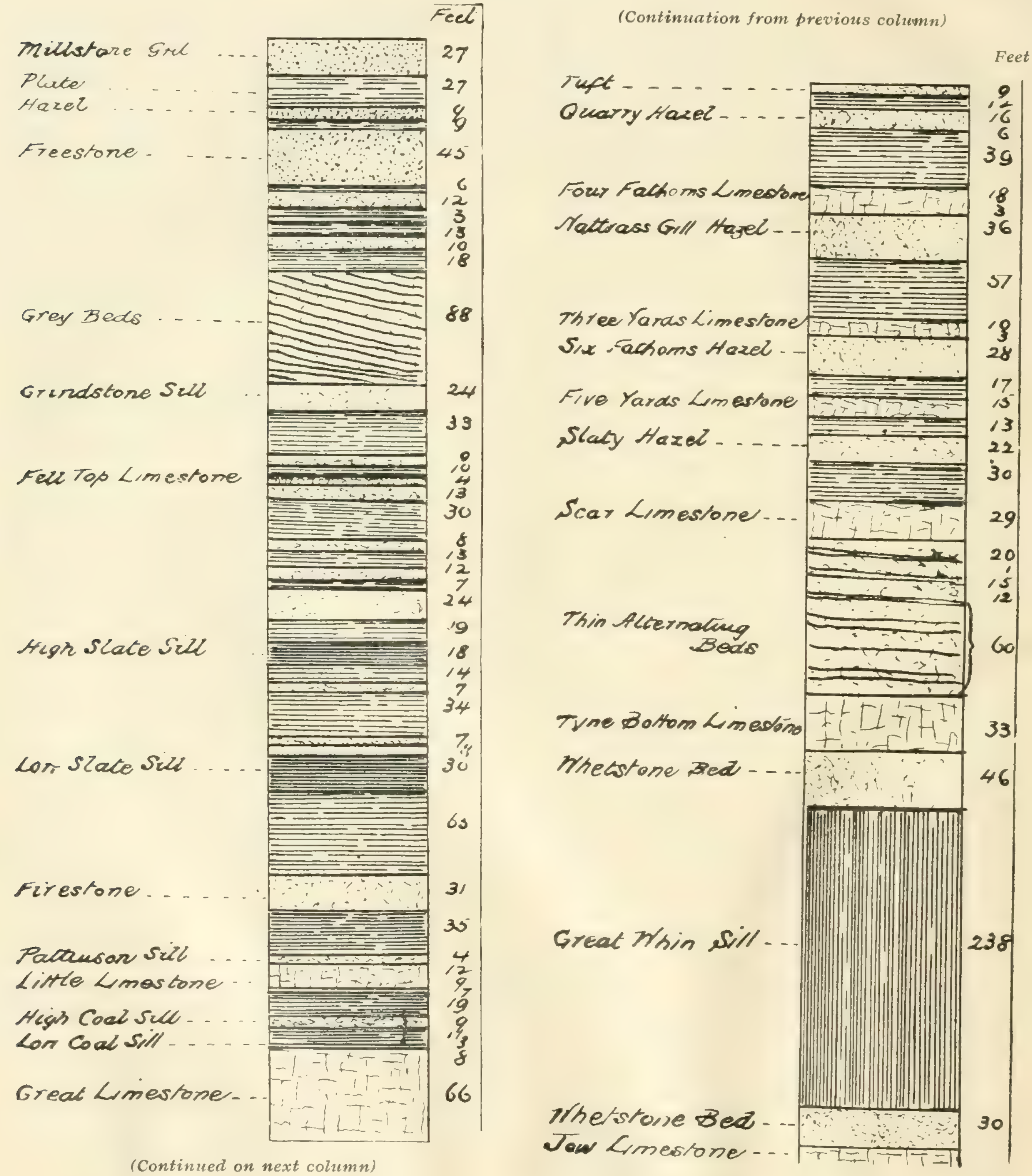


FIG. 4. GENERAL SECTION OF THE STRATA OF THE DISTRICT.

200 ft. in length parallel with the vein; they have no well defined walls, but the limestone, from being almost entirely absent, asserts itself more and more, and gradually carries less and less galena, until it is impregnated with only occasional splashes of ore, and ultimately passes into barren massive limestone. The flats proper contain but little gangue, and are usually filled with galena, occasionally with a certain amount of fluor-spar and rarely any other mineral, though calc-spar, and very rarely quartz also occur; the yield is always high, some of the flats having produced over 10 tons of ore to the cubic fathom. The Great Limestone is the bed that mostly carries these flats, and they may occur at three different horizons, near the top, bottom, and middle of the bed respectively. A section of the Boltsburn vein, Figure 5, showing both North and South flats, may help to a clearer understanding of this mode of occurrence. A practically continuous succession of these flats has extended for half-a-mile along both cheeks of the vein, and they are continuing to open out as the vein is being developed. Not only is the purity of the ore in the flats quite remarkable, but this is in a sense a characteristic of the whole of the Weardale occurrences, zinc-blende being found here only as a mineralogical curiosity, a fact that is particularly interesting, considering that this mineral is extremely abundant in the otherwise very similar Alston district, lying only a few miles away to the northward. Relatively few of the Weardale mines have been followed down to great depth; it is usually held by the old miners that no lead veins penetrate the Whin Sill; it is therefore worthy of note that of the two mines that have pierced this Sill, Burtree Pasture vein is stated to have been fairly rich in lead where it traversed the eruptive rock.

Nothing at all is known as to the period when lead mining commenced in Weardale, but it is beyond question that it goes back well beyond the times of which we have any definite records. There is no evidence, such as there is in other parts of Britain, that the Romans mined lead here, but the discovery of two Roman altars, one at Stanhope and one on the Rookhope Burn, together with various other Roman remains, are conclusive evidence that the Romans penetrated even into this remote dale, and it is highly probable that the rich lead deposits of the district did not escape their notice. It will be remembered that Pliny states that in Britain lead ore occurs abundantly in the upper crust of the earth, and this phrase would have been quite applicable to the early finds of shoad-stones of lead ore in Weardale, to the importance of which the scars of the "hushes" that still furrow the fell-sides bear conclusive evidence. Of course there is no indication of any working in the dark Saxon ages, and it is not until we come to Norman times that definite information is available; thenceforward however it becomes exceptionally definite and abundant, owing to

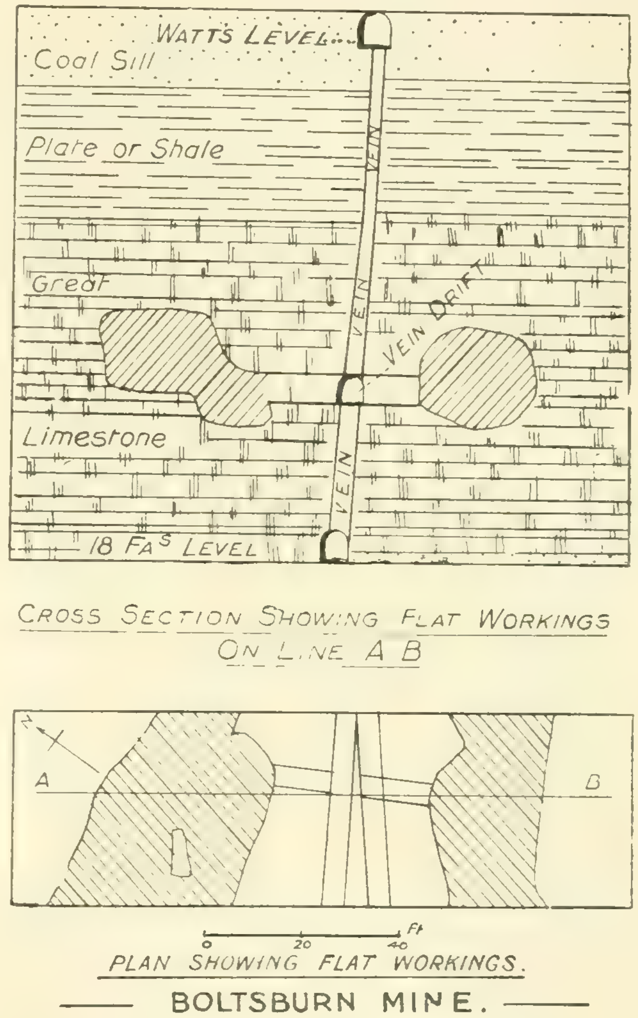


Fig. 5.

the fact that the district of Weardale was in the hands of the lordly Bishops Palatine of Durham, and that constant references to it occur in the Durham archives. The district would unquestionably be included in the grant, said to have been made to the see of St. Cuthbert by Guthred of Northumbria, of the whole country between the Tyne and Tees, probably about 850 A.D.; but the first specific reference to Weardale occurs in the year 1135, when King Stephen granted absolutely the "Minariam de Weredala" to Hugh Pudsey, Bishop of Durham. It is important to note the above phrase, because it shows conclusively that mining in Weardale had become a recognized and established industry even before this date. If Guthred's grant had already given to the Bishops of Durham any effective ownership of the district of Weardale, they would no doubt have asserted their rights over the mines also, so that the grant of Stephen may have merely signified that in this region the Crown would not press its claims to the ownership of all mines, which it did not hesitate to maintain against subjects less powerful than the Bishops Palatine. Or it may have been a confirmation of an existing weak or uncertain title, or again may have been intended merely as waiving the rights of the Crown to the Mines Royal, that is to say, to the silver-producing mines in Weardale. In this connection it should be remembered that from a very early date the Bishops of Durham had their own Mint, and were entitled to coin money. It is beyond question that the lead mines at their outcrops were very much richer in silver than they now are in depth, this phenomenon of surface enrichment being quite familiar in most silver-mining districts. Even in recent times, float galena assaying as much as 120 ounces of silver to the ton has been picked up, though we know of no veins even remotely approximating to this richness to-day.

We meet with accounts of the charges for extracting silver and working it at the Durham Mint in the year 1196, and again in 1213, and similar references occur on the Pipe Rolls during the reigns of Henry III and Edward I, when the see of Durham was for short periods in the hands of the Crown. In 1379 we find a record of a Lease of "Mineram plumbi in alta foresta nostra de Weredale" at a royalty of one-eighth of the smelted produce. There are various lead-mining accounts for the 15th century among the Durham archives, from one of which it appears that lead was still being smelted in the ancient fashion at "les Bolehill" at Wolsingham. During the time that Cardinal Wolsey held the Bishopric of Durham he directed a survey to be made of all lead, coal, and other mines within his bishopric, and he has left other evidences of the importance he attached to the lead mines within his Lordship, not the least interesting being the attempt made by the Cardinal to "melt and try lead with sea-coals" at Gateshead. The Cardinal was in advance of his age, and the trial appears to have been a failure, for in 1527 he granted a lease of his Gateshead furnace and of all mines of metals and minerals "within the country called Weardale" for a term of 30 years at £5 a year. Curiously enough this rental remained in force for a century, as we learn of the same rental being paid in 1626; it is not clear whether a royalty on the lead extracted was paid in addition or not. In 1696 the Weardale lead mines were leased to W. Blackett, the royalty being apparently one-ninth. About this time the Rector of Stanhope brought suit to establish his claim to a tithe of certain of the lead ores, and obtained a verdict in his favour. It was practically this same time too (1692) that witnessed the foundation of the famous company, usually spoken of as the London Lead Company, but the proper title of which according to its charter was "The Governor and Company for Smelting down Lead with Pit Coal and Sea Coal." Patents for smelting lead ore with "pitt coal" were granted in 1678 and again in 1690, so that success was only attained a century and a half after Cardinal Wolsey's unsuccessful attempt. The London Lead Company commenced with smelting works at Bristol, but gradually extended its operations all over the kingdom, and among other localities leased a number of the mines in Weardale at the commencement of the 19th century. In 1801 it leased a number of mines and a smelt-mill on Stanhopeburn, and it is recorded that in 1809 it paid the bishopric of Durham over £5,000 in royalties. Most of the other Weardale mines were leased to Colonel Beaumont, who held under lease from the Bishopric 17 mines in 1809. In that year there were three smelt-mills in operation in Weardale, and the mines were producing important quantities of lead ore. Breckon Syke and Wolfcleugh are named as among the richest mines, the former having produced 10,000 bings (=4,000 tons) of lead ore in one year. In 1821 there were 36 mines working at Weardale, which produced about 17,000 bings (=6,800 tons) of lead ore. An event of some importance in the history of Weardale was the constitution of the Ecclesiastical Commissioners in 1836, who from that time forth took the place of the Bishop of Durham as owners of Weardale, both as regards the surface and the mining rights, the Beaumont family continuing to hold the mines on lease from the Commissioners. Mr. W. B. Beaumont, born in 1792, was one of the most energetic of the lessees, and in his time Weardale prospered exceedingly. His mining office was situated at Newhouse, near St. John's Chapel, and it was here that for over half a century the miners' annual pay took place, and the quarterly bargains were let. The Beaumonts continued to hold the mines until 1880, and then, the price of lead being low and general conditions of mining unsatisfactory, they relinquished their leases and thus ended their long tenure of the Weardale lead mines.

Three years later, namely in 1883, the Weardale Lead Company Limited was formed to take over the mines in this district on a 60 years' lease from the Ecclesiastical Commissioners. The mines then working were Killhope Head, Greenlaws, and Grove Rake, while the famous Burtree Pasture mine, Boltsburn, and Stanhopeburn mines were still open. The company was formed in June 1883 with a capital of £200,000 in 50,000 shares of £4 each, the original directors being Messrs. George Richardson (Chairman), Benjamin Broughton, George Hopkins, Joshua Manfield, Tufnel Southgate, and George Batters; Mr. W. J. Lavington was the secretary, and the offices were at Dashwood House, New Broad Street; the first manager was Mr. James Blenkiron. Operations were not at first attended with any great success; up to 1900, the capital paid up had reached close on £112,000, while the total sum paid in dividends had only been £15,275 in 17 years. For the last ten years of this period no dividend at all had been earned, in spite of the fact that the flats in Boltsburn mine, destined to become subsequently one of the main sources of ore supply, had been cut in 1892. There was a change of management in 1898, when Mr. Errington Thompson was appointed manager, and two years later, namely in 1900, it was decided to wind up and reconstruct the company for the purpose of reducing the uncalled liability on the shares, £2. 5s. 0d. having by this time been paid up on each £4 share. The present company was formed on September 18, 1900, with a capital of £100,000 in £1 shares, of which 97,919 were issued, the old shareholders getting two £1 shares, credited with 15s. per share paid up, for each of their old £4 shares with £2. 5s. 0d. paid, no further cash payments being then required from them.

The directors of the new company were Messrs. George Richardson (Chairman), George Hopkins, Francis George Lane, and John Cameron Swan, the last named having taken a leading part in the negotiations that led to the reconstruction. Mr. Alfred Pegler, who had been associated with the old company since 1887, was appointed secretary. The fortunes of the new company, though not brilliant at first, soon showed signs of improvement, and ever since 1905 the company has been paying steady dividends and in every way securing its position. Mr. Axel F. Ericsson joined the board in 1907, and on the retirement of Mr. Richardson in 1916, he was elected chairman of the company. There was another change of management in 1910, when Mr. Thompson retired, and Mr. H. S. Willis, the present manager, who had been manager of the London Lead Company's mines in Teesdale up to the time of the final winding up of that grand old company in 1903, was appointed to the management.

It need hardly be said that the price of lead is a dominating factor in the prosperity or ad-

Boltsburn Mine.

versity of such a company as the Weardale Lead Company Limited, and its fortunes necessarily fluctuate with the market price of their principal product, although it may be noted that since 1898 the company has been raising and marketing important quantities of fluor-spar. Thus the low lead prices ruling from 1893 to 1895 were in large measure responsible for the winding up of the first company, while the better prices of 1900 and 1901 helped the new venture to get a fair start. Prices again however ruled comparatively low from 1902 to 1905, and again from 1909 to 1911, but by this time the company was luckily so firmly established that it was able to tide over these lean years, and may now be said to have attained a thoroughly sound position.

The company has of course had its share of labour troubles (and which mining enterprise in Great Britain has not?), but of late years these have been minimized by the regulation of wages upon a sliding scale according

TABLE I.—OUTPUT FOR EACH OF YEARS (ENDING JUNE 30) 1884 TO 1916.

Year ended June 30	Ore	Fluor-spar	Pig Lead	Average price of Pig Lead	Principal producing Mine or Mines	Remarks
	Tons. Cwt.	Tons Cwt.	Tons	£ s d.		
1884	3,015 19	—	1,173	10 17 9	Greenlaws	Smelting commenced December 1883.
1885	3,111 13	—	2,462	10 15 2	Greenlaws & Groverake	
1886	4,061 19	—	2,314	12 5 4	Groverake & Greenlaws	
1887	5,440 13	—	3,625	12 4 5	Groverake, Greenlaws & Killhope	Burtree Pasture suspended
1888	4,768 11	—	3,557	12 14 8	Greenlaws, Groverake & Killhope	
1889	3,821 16	—	3,566	12 19 7	Greenlaws & Killhope	
1890	5,444 1	—	3,303	12 17 0	Groverake, Killhope & Greenlaws	
1891	4,309 2	—	3,078	13 0 2	Groverake & Greenlaws	
1892	2,794 1	—	2,947	11 7 6	Do.	Boltsburn Flats cut.
1893	3,851 4	—	2,769	10 2 10	Do.	Middlegrove Level Killhope suspended
1894	4,908 1	—	3,315	9 9 7	Groverake, Greenlaws & Boltsburn	
1895	2,738 2	—	2,706	9 11 6	Boltsburn, Groverake & Greenlaws	
1896	2,462 1	—	2,141	10 17 0	Boltsburn, Greenlaws & Groverake	Trial made on Old Fall and Lodgefield
1897	2,245 2	349 11	1,841	11 5 1	Do.	Greenlaws suspended except for a little tributing
1898	2,130 10	1,483 14	1,952	12 12 2	Boltsburn & Groverake	
1899	1,877 17	2,426 17	1,535	13 4 0	Boltsburn	Old Fall shaft sunk to 150 feet
1900	2,294 7	2,872 6	1,738	16 5 1	Do.	
					Company then reconstructed	
1901	3,276 7	3,514 6	2,391	14 13 5	Boltsburn	Wolfcleugh reopened
1902	2,340 17	3,554 19	1,877	11 4 1	Do.	Greenlaws suspended
1903	2,596 15	3,481 5	2,080	11 5 11	Do.	Groverake suspended
1904	2,305 19	3,679 5	1,819	11 7 8	Do.	Boltsburn dressing floors erected
1905	2,190 10	2,937 19	1,691	12 8 4	Do.	
1906	3,264 12	4,677 9	2,370	15 12 1	Do.	Killhope suspended Stanhopeburn reopened
1907	4,346 10	4,966 9	3,280	19 0 9	Do.	
1908	4,218 11	3,489 15	3,519	15 17 6	Do.	
1909	4,202 0	5,844 12	3,195	12 17 5	Do.	
1910	4,216 1	9,049 00	3,402	12 12 5	Do.	
1911	3,164 10	15,757 17	2,664	12 15 6	Do.	Wolfcleugh suspended
1912	3,778 6	14,189 9	2,643	15 8 5	Do.	
1913	4,943 16	16,639 19	3,587	17 18 8	Do.	
1914	4,687 11	12,505 7	3,709	18 11 5	Do.	Stotsfieldburn reopened
1915	4,168 19	8,861 14	3,644*	19 6 0	Do.	
1916	4,246 11	12,045 17	3,764**	27 17 4	Do.	
	117,222 14	132,327 10	89,657			

* Including produce from 574 tons outside ore.

** Including produce from 1,027 tons outside ore.

to which the men automatically receive an increase over basis rates of pay whenever the price of lead goes up, and by the establishment of a Conciliation Board, upon which masters and men are equally represented, with Mr. Ericsson as chairman, to which all disputes are referred for settlement; fortunately these arrangements have worked to the complete satisfaction of all concerned.

TABLE II.—TOTAL OUTPUT FROM EACH MINE FOR 33 YEARS—1884 TO 1916.

	Ore Tons	Ore Cwt.	Fluor-Spar Tons	Fluor-Spar Cwt.	
Killhope	9,543	11			1892 Middlegrove Level suspended. 1906 all work suspended.
Burtree Pasture	904	14			Suspended 1887
Craigs Level ...	1,042	3			
Greenlaws	16,056	8			Most work suspended in 1897 & 1902
Groverake	18,053	5	8,336	14	
Boltsburn	63,385	15	712	13	
Stanhopeburn...	1,323	8	66,093	7	
Sedling	4,592	14	5,3262	15	
Wolfcleugh	1,639	7	3,399	18	Reopened 1901 Suspended 1911
Miscellaneous...	681	9	522	3	
	117,222	14	132,327	10	

The history of the company's operations may be most conveniently shown in tabular form and for this purpose a synopsis is appended in Tables I and II.

At the present time the company's operations are mainly concentrated at Boltsburn mine. This is worked from a main drawing shaft, used also as a pumping shaft, sunk to a depth of 30 fathoms, where it reaches the Four Fathom Limestone. The principal developments lie northeastward from this shaft, and the workings follow a main level, known as Watt's level, running northeast upon the vein for about two miles. This level has recently been widened and straightened, and haulage, which has hitherto been performed by horses, will for the future be carried on by means of a small oil-fired steam locomotive. Since the main dip of the strata is to the northeastward, the further end of Watt's level is some five fathoms above the top of the Great Limestone. A staple has therefore been sunk about 18 fathoms into the Quarry Hazle, and this has been carried up to surface so as to form a ventilating shaft. The staple is equipped with a small winding engine and set of pumps, driven by compressed air. It may be mentioned that the make of water is not very heavy, the total quantity ordinarily dealt with at Boltsburn shaft being only about 150 gallons per minute. In addition to the winding staple, other staples are holed through from Watt's level to the 18 fathom level, so as to ventilate the leading workings thoroughly. A fan has recently been erected near Boltsburn shaft in order to complete the scheme of ventilation; this fan is connected to an old day drift which communicates by means of inclined road-ways, used as a horse track, down to Watt's level. Mining is performed mainly by rock-drills, the air for which is supplied by a powerful compressor plant at the shaft head; a certain amount of the power required is generated by a large water-wheel, but this does not suffice for all purposes, the deficiency being supplied by steam power.

The dressing mill is situated close to the side of the Boltsburn stream, about a quarter of a mile below the shaft. It is driven mainly by water power with auxiliary steam power. The crude ore or "work" is brought from the mine in trains of mine-trams drawn by a locomotive, and is tipped into a hopper at the mill. Thence it runs over a grizzly which takes out the smalls, and passes over a short picking-belt, on which lumps of clean galena, so-called "potter ore", of clean fluor-spar, and of barren deads are picked off, leaving the dressing ore or "bouse" on the belt. This passes to a 16 by 5 in. rock breaker, whence the broken bouse together with the undersize from the grizzly pass to the usual roughing and fine-crushing rolls, breaking everything to $\frac{3}{8}$ in.; this passes through a sizing trommel, the oversize being returned to the rolls in the usual way. The crushed bouse is lifted by a bucket elevator to a set of trommels, making 5 sizes down to $\frac{1}{8}$ in., each size going to a set of 3-compartment jigs, jigging through the sieve on a bed of clean galena. The hutch-work is clean lead ore, ready for the smelt-mill, though the finer sizes are sometimes finished on a small flat buddle; the middlings or "chats" are elevated to the chat-rolls for further crushing, and the tailings or "cuttings" are lifted by an inclined overhead ropeway and deposited on the waste heap. Everything below $\frac{1}{8}$ in. goes to the slime-dressing plant. It is classified in spitzkasten: the product from the first spigot is dressed on a Record table, the next on old-fashioned round buddles, and the finest on Brunton belts, which latter are here found to be very satisfactory. The heads from the round buddle are buddled again, and the heads from the Brunton belts are usually cleaned in hand dolly-tubs. All the fine tailings are settled in slime pits, whence they are dug out by hand and dressed, for the most part on Brunton belts. The ore is extremely easy to dress, and in spite of the somewhat crude type of

Wolfcleugh Mine.

plant, the results are satisfactory. The dressed ore contains about 78% of lead; it is taken by a narrow-gauge railway to the smelt-mill, situated about one mile up stream from the mines.

Stanhopeburn mine is opened up by an adit about two miles long running westwards from the right bank of the burn. The face of the adit is in the Quarry Hazle, where the vein shows a little ore, though not payable. About 6½ fathoms above the adit or Horse level, another level has been driven in the Great Limestone. The vein here is also comparatively narrow and poor in lead. This pair of drifts is being carried forward in the Red vein, less with the hope of getting good lead ore in this vein than with the expectation of a rich strike where it is intersected by some of the SE–NW veins, which are known to cross it farther to the westward. Farther back the Red vein is very wide, up to 26 ft. in places, and carries a fine body of clean fluor-spar, which is being got by magazine mining. There are two SE–NW veins at present being worked off the Horse level, namely, Reahope vein and Swan's vein. The former shows a promising vein in the Great Limestone. The latter has given satisfactory returns above the Horse level, and has recently been proved below it by means of a staple 16 fm. deep, equipped with hoisting engine and pumps driven by compressed air; at 9 fm. down, a cross-cut driven from this staple has cut Swan's vein, which carries well both as regards lead and fluor-spar.

Sedling Mine is a very old mine; the vein, which is very wide and is said to have been very rich in places, is now worked mainly for fluor-spar, though it still continues to produce a little lead also. It has on the one hand the advantage that all hoisting, pumping, and dressing can be done by water power, but on the other hand the drawback that all products have to be carted about two miles to the railway at Wearhead station.

Prospecting operations are being conducted in Stotsfieldburn and Killhope mines, in the former with very encouraging results. Perhaps one of the most astonishing features of this district is that after active and continuous working for eight centuries, there should still be large areas of virgin ground at comparatively shallow depths, occasionally even above adit level, which promise to yield satisfactory results when opened up.

The smelt-mill smelts all the dressed ore from the mines. The method employed is still that of the old Scotch hearth, which, given experienced and reliable smelters, is capable of holding its own against most modern processes when dealing with a high-class dressed ore. The ore receives a preliminary flash-roast in small reverberatory furnaces, and is then smelted in the usual way in four Scotch hearths, using mainly raw coal as fuel. One of the great objections to the ore-hearth is that it produces large quantities of fume, which must of course be collected and smelted; an unskilled or careless smelter will convert large quantities of ore into fume instead of reducing it. All the furnaces and hearths are connected to a flue, $1\frac{1}{2}$ miles long, running up the side of the valley and terminating in a short stack. This flue is cleaned out at intervals and the fume collected and smelted. Each ore-hearth produces about 2 tons of silver-lead per 8-hours shift when smelting ore, but less than half this quantity of soft lead when smelting fume. The slags produced in these operations, the so-called grey slags, are smelted in a 30 in. water-jacket furnace, producing slag-lead. The silver-lead produced contains about 6 ounces of silver per ton. Experiments are now being conducted in order to determine whether the more modern Huntington-Heberlein process, followed by water-jacket smelting, can replace the old-fashioned Scotch hearth with advantage.

The total number of men engaged in the mines and works was about 400 in 1913, and the average wages throughout all classes of labour were about 30s. per head per week in the same year.

The workshops and mining office of the company are situated close to St. John's Chapel, alongside of the railway line. The London office is in Imperial House, Kingsway, and the present Board consist of Messrs. A. F. Ericsson (Chairman), George Richardson, Frank Richardson, E. P. Deas, and Alfred Pegler (Managing Director).

To engineers engaged in the huge mining and metallurgical undertakings characteristic of modern mining practice, the operations of the Weardale Lead Company may appear to be trivial, but it must be remembered that this is a property which has been a consistent producer for eight centuries, and is still to-day the largest lead producer in Great Britain. It may further claim to be one of the most successful commercially of the present day metalliferous mining enterprises in the country, and it may therefore be of interest to conclude this article by a brief summary of the net pecuniary results of its operations during the 33 years of its existence.

The total cash capital actually expended by the Company amounts to £136,290. It has received for its produce £1,328,075, out of which it has paid away in royalties £64,591 (or 4·86%) ; in rates and taxes £41,490 (or 3·12%) ; for supplies £192,681 (or 14·51%) ; in dividends £178,885, (or 13·47%); and in wages £754,954 (or 56·84%). Seeing how very large a proportion of the payments for supplies is really paid for wages, and the important part that wages form in expenditure not detailed, for instance, for carriage, it is safe to say that fully two-thirds of the receipts have been paid away in wages, while the shareholders have received on their capital during 33 years an average of about 4% per year. The royalties paid amount to 36% of the dividends, and the rates and taxes to 23%. In view of the oft-repeated statements that the capitalist and the landlord are unfairly enriching themselves at the expense of labour, these figures, showing the results over the third of a century of the working of a prosperous and successful mining company may be considered to be well worth putting on record.

Dressing Floors at Sedling Mine.

BUCKET-DREDGING FOR TIN

IN THE

FEDERATED MALAY STATES.

By HARRY D. GRIFFITHS, M.Inst.M.M., M.Inst.C.E.

(*Continued from page 336, December, 1916*).

Chapter II.—Disposing of the Ore—Smelting Charges—Export Tin Duty—Acquiring Dredging Ground—Capitalization of Dredging Companies—Dividends paid by Dredging Companies—Cash Capital Required—Life of a Property—Redemption of Capital—Depreciation of Plant—Head-Office Expenses—Share Quotations—Returns on Investment.

DISPOSING OF THE ORE.—The ore from bucket dredging is invariably sold to the two leading smelting companies, the Straits Trading Co. and the Eastern Smelting Co., which have smelting works at Singapore and Penang respectively and representatives in every mining centre. The sales may be effected in the following manner:

(a) *By tender.*—A parcel of ore being ready for delivery, a sample is sent to each smelting company with a request for a tender for net cash per picul, the smelter taking delivery at the company's dressing shed. The company naturally accepts the highest tender.

(b) *By arrangement.*—In this case the dredging company deals with only one smelter for a stated period of time, after smelting and other charges have been agreed upon. The smelters then supply all bags, twine, etc., weigh and take delivery at the company's dressing shed, provide all transport, etc., and pay in net cash according to the tin quotation for the day, and as soon as the assay of the ore has been agreed upon. The sample is obtained by the rod-sampling of every bag of ore before it is sewn up. Quarter of it is assayed by the company, another by the smelters. In the case of an appreciable difference, and failure to agree, the two remaining portions of the samples are submitted to an independent assayer, whose results are accepted by both parties. The smelting companies generally accept a sale at any time fixed by the dredging company previous to delivery. This enables the dredging company to watch the fluctuations of the metal, and to sell when it considers the price at its highest. As, however, it involves a certain amount of speculation and of worry on the part of the manager, it is not generally resorted to, and the price is fixed on the metal quotation for the day of delivery.

Some companies, instead of selling their ore on the spot, convey it to Singapore or Penang where a higher price for the metal may prevail. This involves more work on the part of the dredging companies and does not appear to give any additional benefit.

The two following actual cases are offered for comparison.

(1) Company in Kinta valley conveys its ore to Singapore where it is sold.

No. 1 ore assaying 75·1 % weight 333·40 piculs
No. 2 „ „ 73·7 „ „ 66·60 „

Net proceeds received in Singapore with tin price at $83·25:

No. 1 ore	$20,134·63
No. 2 „	3,944·05
Total...	$24,078·68
Deduct Costs:	
Tin duty	$2,810·20
Rail and sundries...	176·86
Freight	60·41
Insurance	15·30
Interest	9·74
	$3,072·51

Costs of bags, loading in trucks, etc., not reckoned. Net amount realized by shipment $21,006·14; equal to $52·50 per picul.

(2) Company sells on spot to smelters.

No. 1 ore assaying 75·1% weight 280·00 piculs.
No. 2 „ „ 73·7% „ 56·00 piculs.
Tin price $83·25.
Net amount received $17,549·28 equal to $52·23 per picul.

(c) *By contract.*—In this method, the dredging company undertakes to sell the whole of its output for a stated period, and with fixed and predetermined unit deductions from gross assay, to cover all charges by the smelting company.

These deductions of units from the assay are on a sliding scale according to the price of tin. The company can sell its output on any date, at regular periods, or else daily at the day's price. This latter method ensures to the company an absolute average price and eliminates all possibility of speculation, loss, or fictitious gain. The unit deductions may vary according to the position of the dredging company, its proximity to railway or shipping port, etc.

The following concrete examples will show how the net proceeds for an output are arrived at:

(1) On ore assaying 75·9% of tin, the metal being quoted at $100 per picul, the units deducted to cover all buyer's charges are say 3·5.

Gross assay	75·9%
Deduct units	3·5
Leaves	72·4

This is called the *net* assay.

At $100, this represents per picul	$72·40
Deduct Government tin duty	9·21
Leaves	$63·19

Net cash paid for the ore.

(2) On ore assaying 73%, the tin price being $90, units deducted 3·6.

Gross assay	73·00
Deduct units	3·60
Net assay	69·40
at the price of $90.	$62·46
Deduct tin duty	8·05
Net price realized	$54·46

SMELTING CHARGES.—The smelting and other charges (costs of bags, loading up, weighing, railage, freight, insurance, etc.), necessarily vary according to the locality of a mine, and can only be worked out for each particular case. In the four examples given above, they would appear to have been as follows:

(b 1)	All charges per picul	No. 1 ore	$2·12	per ton	£4	3	3
		No. 2 ore	$2·13				
(b 2)	,,		$3·31	,,	£6	9	8
(c 1)	,,		$3·50	,,	£6	17	2
(c 2)	,,		$3·24	,,	£6	3	0

Taking the first case where the ore was delivered at Singapore, after the company had paid all expenses of delivery, it would appear that the actual smelting charges including smelter's profit are in the vicinity of £4 per ton.

The notable feature of tin sales in the Federated Malay States is that there are no uncertain, varying, and vexatious deductions for weighing, moisture, draftage, etc., as is the case in some other countries, and the miner, knowing the assay-value of his ore, and the official quotation for tin, knows exactly what he will receive for his parcel.

A rough estimate of the realizable value of an output can easily be arrived at, by taking 63% of the tin price on the day of sale. Thus if an ordinary output including both No. 1 and No. 2 ores is sold when the official tin quotation is $85, a value of 85 × 0·63, or $53·55 per picul, represents approximately what will be received in cash. This percentage varies necessarily with each mine according to the percentage of No. 2 ore produced and its assay, but is easily determined after a few months' work has given a fair average.

EXPORT TIN DUTY.—The duty exacted by the Government of the Federated Malay States is not a fixed quantity. It varies according to the price of the metal, as is shown by Table II, which gives the amount payable per picul of ore (assumed to average 70% of pure metal) when tin is quoted from $80 to $115. Taking an average price of tin of $100, the duty amounts to about 12·7% of the gross value of the ore. As the duty shown in the table is only 70% of that payable on the pure metal, and applies to all concentrates whether they carry more or less than 70% of metal, it follows

TABLE II.—FEDERATED MALAY STATES EXPORT TIN DUTY.

Duty per picul of Tin Ore assumed to assay 70% of Metal.

Price of Metal $	Duty on ore $	Price of Metal $	Duty on Ore $
80	6·90 (a)	98	8·99
81	7·02	99	9·10
82	7·14	100	9·21
83	7·26	101	9·32
84	7·37	102	9·44
85	7·49	103	9·56
86	7·61	104	9·67
87	7·72	105	9·79
88	7·84	106	9·92
89	7·93	107	10·04
90	8·05	108	10·15
91	8·17	109	10·27
92	8·29	110	10·39
93	8·40	111	10·50
94	8·52	112	10·62
95	8·64	113	10·74
96	8·75	114	10·85
97	8·87	115 (b)	10·97

(a) Equals 12·32% of gross value.
(b) Equals 13·62% of gross value.

that it is an advantage to export ore of the highest possible grade, and to dress the seconds to no less a value than 70%. The miner is never troubled with the payment of the tin duty, as that is left to the smelting companies to pay. The fixing of the duty for all ores, independently of what their assay-value may be, renders the collection of that duty an easy and simple matter for the Government.

It has been claimed that the export duty in the Federated Malay States is unduly high, and detrimental to the mining industry. As regards the first, the following comparative figures which have been obtained from careful investigations are interesting, and speak for themselves.

Country.	Per centage of Duty to Gross Value.
Federated Malay States (from actual ore sales)	12·7
Siam (average).....................	9·6
Nigeria	10·0
Federated Malay States (from Government Reports)	11·16 to 12·9

In reference to the second contention the Government some three years ago recognized that in certain cases the high duty was a hardship and a possible detriment to mining enterprise, and it was therefore decided to considerably reduce the duty on all ore produced from lode mining where the cost of production per picul is always very much higher than in alluvial propositions. It was reckoned by one lode-mining company that the reduction would correspond to nearly 10% of its capital. The concession was not, however, granted without a quid pro quo in the shape of certain compulsory underground development.

At the present time, the tin-dredging companies which are mostly working ground previously "worked out" and considered valueless, and whose returns per yard are infinitesimal in comparison with an average lode mine, contend that the tin duty as applied to them is excessive and represents too important a percentage on their small profit. An open-cast mine returning 3 catties per cubic yard, when the price of tin is $100, has a realizable value of $1·89 per cubic yard and pays $0·27 in tin duty. The duty therefore represents 14·27% of the value of the ground. The profit on the working being $1·29 the tin duty corresponds to 20·8% of that profit. But in the case of a dredging proposition returning 0·6 cattie per cubic yard, of a value of $0·37 with a working profit of $0·21, the tin duty represents 26·2% of the profit.

A dredging company has from the outset to provide a much larger cash capital than would be required for an open-cast mine, and has to pay almost as much (and in the case of Government ground as much) for its ground, as if it carried 3 catties or more. Under the circumstances it must be admitted that the dredging companies have good grounds for asking more fair and equitable treatment. The Government is asked to realize that if it had not been for private enterprise, unaided by them, they would not have derived any revenue from ground which they always considered valueless for mining, but that owing to the persevering efforts of the miner that ground is now capable of yielding a revenue, and of prolonging the life of the tin-fields. Poor ground can always be granted under agricultural leases out of which a small revenue can be derived. If, however, a substantial one can previously be obtained out of mining the advantage is altogether on the side of the Government, as it is well known that after a very few years, ground which has been turned over by mining is almost as good for agricultural purposes as in its virgin state. There are many instances of worked-out mining ground having been planted with rubber and having given results as good as anywhere in jungle grouud. Concessions in the shape of reduced tin duty, and reduced premiums, for properties averaging one cattie and under would therefore be very welcome to the mining industry. Although the Government may point out that the dredging companies are all making a fair profit and are not, for that reason, entitled to special treatment, the arguments and desiderata still stand, and if recognized they would assist the expansion of the industry very considerably. The Government of the Federated Malay States has always been a progressive one, and it is hoped that when the case is duly presented, the claims will be admitted to the benefit of all concerned.

Acquiring Dredging Ground.—This can only be accomplished in two ways, either by buying known mining ground from owners of mining leases, or else by obtaining new mining leases on Government ground. In the first case it may involve difficult and protracted negotiations in order to secure a continuous block of at least 400 acres (the minimum considered essential for a dredging proposition). Many lessees may have to be dealt with, who each thinks his ground the pick of the lot, and worth more than is asked for by his neighbour, and patience and perseverance are required by the would-be purchaser. The ground is generally secured under an option agreement for a certain term, and for which a sum in hard cash is paid by the purchaser. The time given is generally ample to allow the property to be bored and tested systematically, and to allow financial arrangements to be made for the flotation of a company. On definitely taking up the ground held under option, the purchase consideration consists of cash and of shares in the company. The proportion of cash to shares asked for varies considerably, and in most cases so far, the cash consideration has been unduly high, and out of proportion to the intrinsic value of the ground. Although the owner or lessee of mining ground of low value cannot work it at a profit by ordinary methods, or cannot put up the necessary cash to buy a dredge (providing of course that the extent of the ground is sufficiently large for a dredging proposition), he generally asks for a prohibitive price when a purchaser presents himself. In many instances this rapacity has proved a stumbling block to otherwise promising dredging propositions.

Against this there is no remedy, except to wait until the ground is forfeited through failure on the part of the owner to work his ground according to law, and then to apply to the Government for the land and for a new lease. It is, however, rare that such a forfeiture takes place, as the owner generally has some other profitable ground on which he has been granted the right to concentrate the work and thus protect the title of his poor land. If the land surrounding a block of ground has been acquired and floated into a dredging proposition and the owner still holds out for an exorbitant figure, the Government has the power to interfere by forcibly cancelling the lease, or to bring pressure on the owner to sell at a price fixed by arbitration. It would be invidious to mention the price which has been paid for ground by dredging companies, but there is not any doubt that it is too high, and that combined effort and sustained arguments are still needed by the purchasers.

The second method of obtaining ground is by application for Government owned land. This may be virgin land over which no lease of any kind has been granted, or mining or other land which for some reason or another has become forfeited. In both cases a concession for a period of six months (renewable under certain conditions for another six months) is granted in order that boring and testing may be undertaken. On taking up the land a premium varying from $15 per acre upward is paid to the Government, in addition to survey fees, and a mining lease is obtained.

This is the cheapest way of obtaining mining land, but such land is not plentiful, unfortunately, in the well known mining districts.

Capitalization of Dredging Companies.—The present number of purely dredging companies floated in the Federated Malay States is ten, in addition to which one old-established mining concern has two dredges at work. Since the beginning of the war, no dredging company has been floated in England owing to the restrictions imposed upon the export of capital, although several are in course of preparation for the future. The Australians, who have had for years past important mining interests in the Federated Malay States and who may be considered as the pioneers of bucket-dredging in Siam, have of late shown great activity and enterprise in the Federated Malay States and are responsible for five dredging companies. Several more companies are in course of flotation, so that Australia will have a clear lead in the industry until British capital is again released for employment abroad.

In Table III is shown the capitalization per acre of the different dredging companies. In some instances, marked (?), the acreage is only approximate as more ground is gradually being acquired to round off and enlarge the boundaries. In the other cases the acreage is that on which the companies were floated.

The table shows that in the most recent flotations the average capitalization is higher than that of the pre-war companies, and this is due not only to a higher price having been paid for the ground, but also, owing to the higher cost of dredges due to the war, a larger sum in cash having to be provided. When normal conditions are again re-established it is probable that a capitalization of £200 per acre will not be exceeded, and on that basis a fair and steady return on investment should be secured.

Dividends paid by Dredging Companies.—Few companies had their dredges working during the whole of 1915. A return of the dividends paid during that year cannot be taken as a criterion of what can be accomplished, but is of sufficient interest to be shown in Table IV.

The table indicates that all the companies which have had dredges at work during the first half of 1916 are paying dividends, and that so far not one single failure has been recorded. The prospects of those companies

TABLE III.—CAPITALIZATION OF TIN-DREDGING COMPANIES.

Name of Company	Where floated	Nominal Capital £	Acreage	Capitalization per acre £
(a) Tekka Taiping, Limited	England	90,000 Issued 65,000	2,000	45
(b) Malayan Tin Dredging, Limited	England	125,000 Issued 121,000	1,250(?)	100
(c) Trong Tin, N.L.	Australia	80,000	720	111
(b) Chenderiang Tin Dredging, Limited	England	120,000 Issued 92,500	927	129
(c) Bentong Tin, N.L.	Australia	100,000	500	200
(a) Assam Kumbang Tin Dredging, Limited	Australia	100,000	500	200
(b) Ipoh Tin Dredging, Limited	England	90,000	420	214
(a) Kamunting Tin Dredging, Limited	England	150,000 Issued 130,000	497	302
(a) Kampong Kamunting Tin Dredging, Limited.	Australia	150,000	402	348
(a) Larut Tin Dredging, Limited	Australia	75,000	172	436
(b) Tronoh Mines, Limited*	England	160,000	2,000(?)	—

(a) District, Taiping Valley
(b) District, Kinta Valley
(c) District, Pahang

Average capitalization per acre £146
Average excluding Tekka Taiping ...£183

* Total dredging area exceeds 700 acres.

TABLE IV.—DIVIDENDS PAID BY FEDERATED MALAY STATES TIN DREDGING COMPANIES.

Name of Company	Capital £	No. of Dredges	Time of Working Months	Dividends paid in 1915 %	Tin Price 1915 $	Divi. paid to June 30 1916 %	Tin Price to June 30 1916 $
Malayan Tin D. Ltd.	125,000	3 1	12 4	10	78·17	10	90·19
Chenderiang T.D. Ltd	120,000	1	8½	2½	,,	2½	,,
Kamunting T.D. Ltd	150,000	1	9½	15	,,	5	,,
Tekka Taiping Ltd	90,000	1	3	—	,,	10	,,
Ipoh Tin D. Ltd	90,000	1	4	—	,,	5	,,
Kampong Kamunting T.D. Ltd...	150,000	1 1	9½ —	—	—	7½	,,
Tronoh Mines Ltd	160,000	1	12	*Reported profit £13,550 from dredges for 10 months	—	—	,,

* Directors' Report December 31, 1915.

now building dredges are as good as any of those now working. It is interesting to note from the following table on what returns per cubic yard the results have been accomplished. The official returns for 1915 are as follows:

Company	Catties per cu. yd.	lb. per cu. yd.
Malayan Tin D.	0·49	0·65
Chenderiang T. D.	0·56	0·74
Kamunting T.D.	0·96	1·28
Tekka Taiping	0·74	0·70
Ipoh Tin D.	0·62	0·82
Kampong Kamunting	0·79	1·05
Tronoh Mines	0·55	0·73

That such low returns could have yielded profits is remarkable, and would, a few years ago, have been considered impossible. Improvements in the design of the dredges, in practical working, and in management tend daily to reduce the working costs, and in this respect the last word has not been said, and still better results will be obtained in the future. It is certain that half-cattie propositions will give a substantial profit, and that almost every acre of the flats in the main valleys will be worth working by bucket dredges.

CASH CAPITAL REQUIRED.—Whatever may be the size of the property, it has been so far the rule to provide only such cash capital as will provide for all preliminary expenses, and for the construction of only one dredge. For such properties whose area may call for more than one dredge, the additional cash may be partly provided out of profit, or else by the issue of reserve shares, or of debentures carrying a fixed rate of interest, redeemable after a number of years, or convertible into ordinary shares of the company. The latter is not greatly favoured as it considerably increases the nominal capital, and causes a reduction in the dividends. An opportunity is generally taken of issuing reserve shares at a premium when the shares of the company are above par. This ensures no increase of capital, and to a certain extent helps to keep up the market price of the shares. The Malayan Tin Dredging Ltd. is a good example of sound financing, as without so far having increased its nominal capital of £125,000, it has been able to secure four powerful dredges without affecting the rate of dividends and to still keep 4,000 shares in reserve. The actual cost of the dredges must have been nearly as much as the issued capital of the company.

The cash capital required for a dredging proposition has increased since the beginning of the war, owing to the price of material having risen considerably. Previous to that time, it was possible to construct a dredge of 90,000 yards capacity for about £30,000, but at present about 40% more is required.

When conditions become normal again, the cash capital in any flotation should provide for:

(1) For part payment of property.
(2) For preliminary and flotation expenses, say £3,000
(3) To cover boring expenditures, reports, etc £2,000
(4) Construction of one dredge. £30,000
(5) For making paddock, erecting necessary mine buildings, native quarters, etc. £3,000

On this basis there should be no possibility of the working capital being inadequate, and even a small reserve fund might remain.

The fixing of the nominal capital is naturally left to the promoters and guarantors of the issue according to the size and life of the property, amount to be paid for same, etc., and in such a way as to leave them a clear majority of shares to control the undertaking. There is of course no moral reason for the latter, but it has been so consistently the case in mining concerns, that the suggestion of a change would probably be considered revolutionary. The general practice so far would indicate that about £180 per acre would be a fair capitalization for a Federated Malay States dredging property of not less than 500 acres.

LIFE OF A PROPERTY.—This is determined by the average dredging depth of the deposit and by the number of dredges it is proposed to use. A standard capacity of 90,000 cu. yd. per dredge per month is now assumed, and a dredge is reckoned to have a useful life of 10 years. The monthly acreage worked out per dredge of that capacity varies according to the districts from 1 to $1\frac{1}{2}$. It is therefore easy to compute the life of a property after a few months work has established the average dredgeable depth and capacity of the dredge.

REDEMPTION OF CAPITAL.—In the case of a short lived property it is useful and advisable to redeem the capital by yearly drafts on the profits and to create a reserve fund which on exhaustion of the mine would be nearly equal to the nominal capital of the company. Although this reduces the actual amount of dividends paid to shareholders it enables the company to seek new ground or new investments with more cash than it had at the onset, and to face any financial difficulties that may happen in the meantime.

The policy is certainly a wise one and it is being followed in some instances. The Kampong Kamunting company, having a capital of £150,000 (140,000 issued) and having calculated the life of its property at 10 years working with two dredges, redeems yearly out of profit the sum of £9,000. It is reckoned that with interest at 6% this reserve fund at the end of the 10 years should represent something like £105,000. In addition to this redemption, the usual amount of depreciation of all plant and buildings is written off yearly. The directors reckon that under these circumstances a regular dividend of 30% can be maintained. (See the directors' report for the half-year ended February 29, 1916).

DEPRECIATION OF PLANT.—The life of a dredge being reckoned at 10 years, the depreciation should be about 10%, but most of the companies write off yearly a depreciation of $12\frac{1}{2}$% which also bears on all additions to plant. For buildings and other plants it varies from 10 to 20%, as shown in Table V.

HEAD OFFICE EXPENSES.—Most of the dredging companies publish every month the result of the work together with the mine expenses and profit. The latter is often estimated only, but is sufficiently accurate to serve as a basis for calculating what the rate of dividends may be for a certain period.

In order however to arrive at a fair approximation it is necessary, as well, to know what amount the depreciation will be, and what the general head office expenses amount to. These can be obtained by studying the yearly balance sheets of the companies. Under head office expenses are included the directors' fees (generally a fixed sum), the directors' bonus or commission, secretarial and office expenses, cables, stationery, etc. In many cases the trust deed provides for a directors' commission of a fixed percentage on

Table V.—Depreciation Allowed.

Company	Depreciation on Dredge %	Depreciation on Buildings %	Depreciation on Other Plants %	Depreciation on Furniture, etc. %
Kamunting T.D., Ltd.	10	9	9	9
Kampong Kamunting T.D., Ltd.	—	10	20	20
Tekka Taiping, Ltd.	about 12½%			
Chenderiang T.D., Ltd.	12½	10	10	—
Malayan T.D., Ltd.	12½	10	10	—

Table VI.—Yearly Head-Office Expenses.

Company	Directors' Fees £	Directors' and Manager's Commission £	Secretary and Offices £	Sundries £	Total £	% Of Mine Expenses
Chenderiang T.D., Ltd.	1,000	—	693		1,693	9
Kampong Kamunting, T.D., Ltd.	1,000	—	304	345	1,649	10
Tekka Taiping, Ltd.	446	—	232	165	843	6
Kamunting T.D., Ltd.	—	—	—	—	1,461	10
Malayan T.D., Ltd.	500	2,412	250	1,019	3,381	8
Ipoh Tin Dredging, Ltd.	500	—	200	403	1,103	11

Table VII.—Showing Valuation of Shares in Tin-Dredging Companies.

Company	Dividend paid in 1915* %	Price of Shares Dec. 31, 1915	Dividend paid 6 months to June 30, 1916†	Price of Shares June 13, 1916	Tons produced 1915	Tons produced 6 months 1916
Kamunting T.D., Ltd.	15	30s.	5	35s.	529	297
K. Kamunting T.D., Ltd.	*nil*	29s.	7½	42s. 6d.	—	402
Tekka Taiping, Ltd.	*nil*	42s.	10	46s. 3d.	71½	264
Chenderiang T.D., Ltd.	2½	19s. 6d.	2½	18s. 9d.	288½	183
Malayan T.D., Ltd.	10	31s. 3d.	10	46s. 3d.	712½	603½
Ipoh T.D., Ltd.	*nil*	14s. 6d.	5	18s. 9d.	94½	134½

* Average price of Tin per picul in 1915......$78·17. † Average price 6 months of 1916......$90·19.

the profit remaining after a certain dividend has been provided for the shareholders. As an instance, a company pays a commission to the directors of 5% of the profit remaining after the shareholders have received 15% in dividends for the year. This item must be reckoned in working out the total dividend which the shares are likely to carry.

From a careful perusal of the latest directors' reports, Table VI, given above, has been compiled.

It would appear therefore that the ordinary head office expenses on an average come to 9% of the mine expenditure. In making anticipatory calculations, the uncertain elements are the amount of depreciation and the amount that the directors will carry over as a reserve fund for acquisition of further ground, plant, or investments.

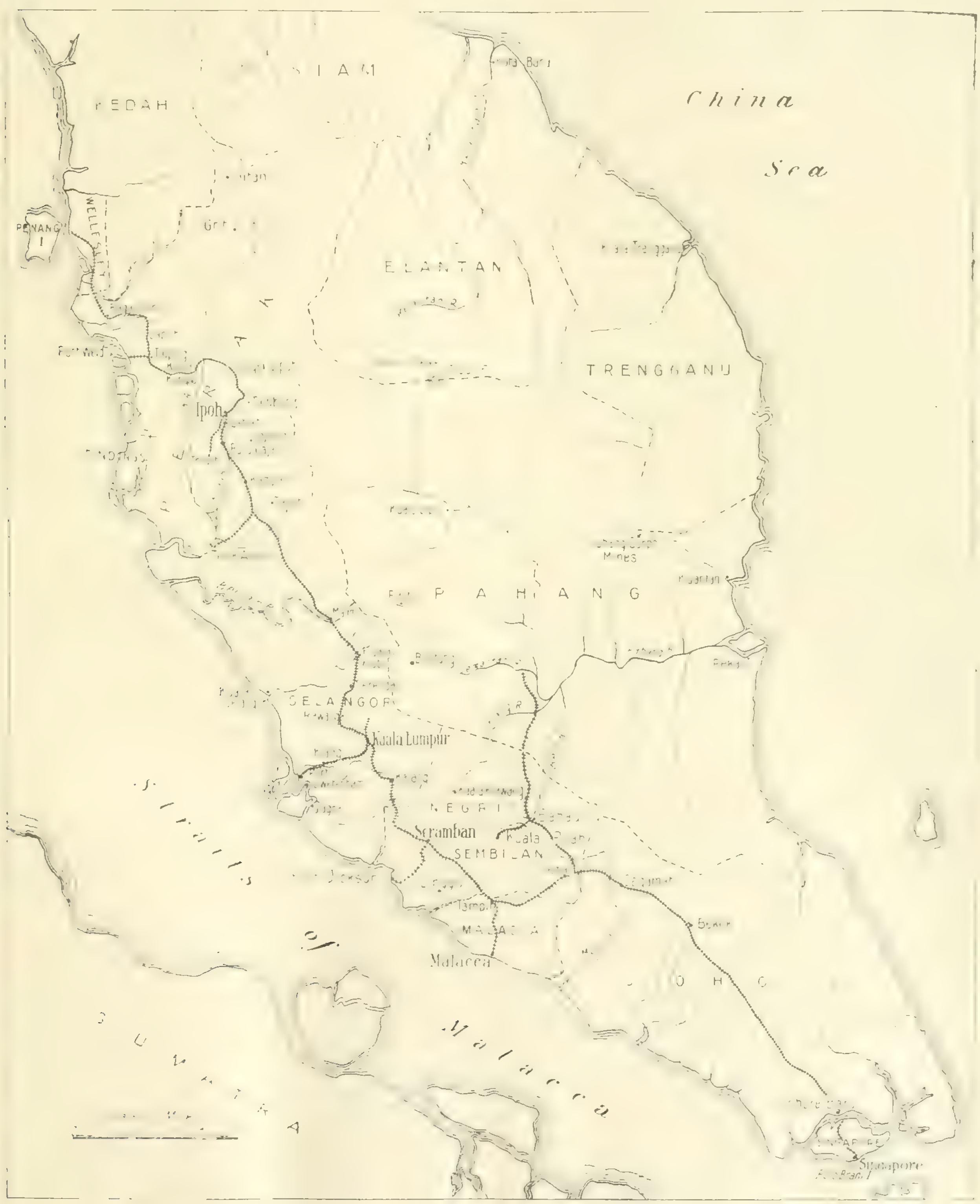
Share Quotations.—In ordinary times the quotation of well known shares is generally a fair criterion of what the dividends should be. It is generally reckoned that a dredging investment should give a minimum of 12%. If a concern therefore pays 24% and is reckoned to have a fairly long life, the £1 shares are considered worth something in the vicinity of £2. Tin-dredging shares are however subject to more uneven fluctuations than other mining concerns owing to the fluctuations in the price of tin. The uncertainties of the war and the consequent dislocation of the money markets make the tin share market very sensitive, but it is hoped that these are only temporary, and that a greater steadiness will prevail in the near future. Table VII, although compiled from conditions prevailing in times of stress, shows what values are now placed on shares in tin-dredging companies.

Returns on Investment.—In view of the profits being made at the present, and after very careful inquiries on the spot, the returns on investments in Federated Malay States dredging companies when conditions become normal should be as near as possible as follows:

Tekka Taiping*	35%
Kampong Kamunting	30%
Malayan Tin Dredging	30%
Kamunting T.D	25%
Ipoh Tin D.*	15%
Chenderiang T.D.	10%

* This is capable of considerable increase when further dredges are obtainable after the war.

(To be continued).



Map showing the Federated Malay States.

DISCUSSION

Conditions after the War.

The Editor:

Sir—I read your editorial "After the War —What?" in your July issue with the greatest satisfaction. It has seemed to me that the economic issues created by the war are generally misunderstood. Even many of those writing for the supposed guidance of the public appear to fail to grasp the facts. There is certainly danger that the war will result in or be followed by a period of economic dislocation which would entail great distress. The danger, however, is not that such will be caused by circumstances beyond the control of man, but that it will be caused by man adopting the wrong course of action, or rather by his meeting the situation in the wrong spirit.

The wrong course of action is that of timidity and lack of confidence, every man waiting to see how matters go before he commits himself to any risk. The right course is that of courage, energy, and confidence, every one unhesitatingly following such enterprise and industry as falls to his hand, and the application to industry of State and individual intelligence. If this course be taken, no losses either in goods or in men, that are within the limits of probability, caused by the war, can impose poverty on the community or communities concerned. The issue is indeed almost wholly psychological. Given certain natural resources, a community can, within wide limits, make its wealth what it chooses, the price paid being the exercise of energy, some temporary self-denial (which is an exercise of moral energy), and intelligence (which is mainly mental energy). Losses caused by an event such as the war, huge though they may be, are not overwhelming compared with the productive capacity of a people working hard and intelligently (the latter inferring proper organization).

The first and most important step in influencing a people psychologically is to establish faith in the public mind. Faith, again, should be based on knowledge. What is wanted is that the public should know that all will be well in an economic sense if it, as a whole, deserves well. On that knowledge it should have faith that all will be well and in that faith meet the situation in the proper spirit. It is then of the utmost importance that the public should have that knowledge, that is, should understand what will cause poverty or create prosperity. That knowledge can be imparted best, one might say only, through the press. I believe therefore that the press should expound the economic situation vigorously and continuously.

Your editorial is sound sense throughout, and any serious student of economics will endorse every word of it. My belief, however, is that the facts outlined in it are not recognized by as many as should be the case, hence the need for preaching a sort of economic gospel.

It seems generally assumed that all the combatant nations will be much poorer at the close of the war and will remain so indefinitely or for a very long period. The assumption is apparently based on the fact that an enormous wastage is caused by the war. This assumption ignores other factors of equal importance. Those other factors are production and economy in other directions. If these can be increased, they are obviously offsets to the wastage. It seems to be assumed by many that these must remain as before. As a matter of fact they can vary just as much as the wastage can; absolutely, if not relatively. The establishing of economic truths in the minds of the majority is not always easy. In this case, however, we have the proof of a people's ability to increase production and economy. Both have greatly increased during the war. The question is then whether, when all the factors of wastage, increased production, and increased economy are balanced, the belligerent nations will be poorer or not. Briefly, the answer is that it remains with the peoples as to whether the last two items exceed, equal, or are less than the first.

The issue is worth closer analysis, and the first step in doing so is to define the issues and the meaning of words used. The discussion is confined to the case of the belligerent nations, and more particularly to Great Britain. It is obvious that, as regards the world as a whole, the only possible losses (that is in wealth, for we are not discussing moral or other issues) are the productive capacity of the men put out of action and the material destroyed. These, compared with the wealth —accumulated and being produced—of the world must be very small. The belligerent nations, it may be accepted, incur all that loss, and additionally may have to exchange with outside nations some of their accumulated wealth for material which will be destroyed in the war. It might be assumed then, at first glance, that they would be left much poorer. This will be dealt with later.

Production is the real wealth made during any given period. National production is the real wealth made by a community as a whole. It is measured (allowing for variations in level of prices) by the incomes of all the units of a community being added together. It might appear that the income derived from foreign investments is not part of national production, and that such income represents part of the production of the countries where the money is invested. As capital (accumulated wealth) is admittedly productive, such income may for all practical purposes be included in the national production of the country owning the investments.

National economy, or savings, is the allocating of a portion of production to create or increase accumulated wealth, instead of its dissipation to evanescent purposes, such as higher living, pleasures, etc. From the standpoint of increasing accumulated wealth, dissipation of production is equivalent to wastage. National income is derived from two sources, interest on capital (accumulated wealth), and income earned. The national wealth (or prosperity) can fairly be measured by the total income (or production) regardless of what proportion of it is due to interest. Average individual wealth (or prosperity) is measured by the total income less the State expenditure on work which may be regarded as wastage divided by the units comprising the community. Military and naval and other defence expenditure for economic purposes can be regarded as wastage. Civil administration expenditure is supposed to give real value, in that it confers benefits and performs such duties as would in any case have to be performed in order to fittingly carry out civil life. This means that such expenditure is necessitated by internal requirements. Wastage may be taken as the expenditure on external affairs, or on losses caused by external agencies. Thus the naval, military, and other defence expenditure would include the cost of the war, the provision for the disabled, for dependents of killed and disabled, any financial assistance given to nations such as Belgium and Servia, etc. It is not suggested that expenditure on defence or other objects is unnecessary or useless. It is most necessary. The point is that, to arrive at the wealth available to the people for the individual benefit, this expenditure (or partial diverting of energy to ends other than that of production) must be deducted. In an economic sense only is it wastage.

The question more clearly defined then becomes : need national production (income measured in real wealth) available for the people after providing for expenditure on defence, etc., be less after the war than just before it? If so, need it be so decreased that it cannot be counterbalanced by economy, such economy to be such only as would not affect the national moral, mental, or physical well-being? The answer is that there is no need for such, and indeed that such income can be increased.

During the war no doubt the national income available for individual benefit will be less than before the war; still the people are fairly prosperous. No doubt also some of the national accumulation of wealth will have disappeared. The people would not be doing their duty otherwise. Regarding decrease in accumulated wealth, this, in the case of Great Britain, will probably be mainly out of foreign investments. There will be also losses of ships, a few buildings, etc. These last may or may not be counterbalanced by the value of factories, new ships, etc., built during the war.

Admitting that the people are poorer, have to exercise more economy, during the war, what about after the war? There are two factors to consider, the decrease of accumulated wealth at the date of the war closing, and the balancing of wastage, production, and economy (savings) afterwards. The decrease of accumulated wealth can be caused only by realization of part of such to foreigners, by actual destruction of property, and by the borrowing of money (by the State or individuals) from foreigners. The last of these, in the case of Great Britain, is a negligible quantity. It is not probable that the first can attain very large dimensions. To do so, it must be assumed that foreigners will invest extensive savings in buying the said property (accumulated wealth). There is no reason to believe that they would do so, or are doing so to a large extent. They will probably do so (or have done so to some extent) out of the temporarily increased profits due to war demands. It seems that the United States is doing so. Such realizations, however, do not appear to be on a very extended scale, and apply anyhow only to foreign investments. The national loans are internal, and it is certainly improbable that there is any extent of private borrowing from foreign sources. Anyhow, foreigners have at present no special stimulus to increase their savings wherewith to increase their capital, and this would be necessary if they are to absorb the capital of the belligerent nations.

It appears then that the national capital is unlikely to be decreased greatly through the war. This means that the wastage of the war must and will be supplied almost wholly from savings. Now the wastage during the war is enormously greater than it will be after the war. We have then the fact that the nation is fairly prosperous in spite of the enormous wastage, most of which will disappear at the termination of the war. If then, production be kept merely at the same level, there will be a greatly increased income, which can be used for the people's benefit, over that during the war. Yet during the war, the people are fairly prosperous. If production be increased after the termination of the war, as should be the case, the said income would be still further increased.

How will the combined wastage, production, and economy compare with that before the war? The wastage will be greatly increased, by the maintenance of disabled men and of the dependents of killed and disabled; probably also by a considerable increase in defence expenditure. Production will be what the people make it. In spite of the withdrawal of millions of workers, the national production is apparently greater now than before the war. If the same energy is maintained it will again be greatly increased on the return of millions of workers. Allowing that it is well that many of the women should not continue working, or should work less strenuously, for reasons of national health and vitality, it seems certain that production can be made much larger than it was prior to the war.

Regarding economy, it has been shown that this must have been exercised during the war, that is, that savings have practically counterbalanced the enormous wastage. If then, production remains the same as during the war or be increased, the wastage be greatly decreased, and the same economy be exercised, the nation would rapidly add to its capital. There is, no doubt, a middle course, which would make possible more expenditure on individual benefits, yet enable savings reasonably rapidly to overtake any decrease in capital, and to then increase it while allowing fully for the increased wastage as compared to before the war. It is certain then if the same amount of energy and intelligence is put into production and economy after the war as is being exercised during it, the nation will be richer than before and will be adding to its capital.

Personally, I have faith that the great national awakening now being experienced will result in an increased national activity. However that may be, the spreading of that faith cannot but add to the desired result.

H. R. SLEEMAN.

Perth, W.A., November 13.

"Eclipse or Empire."

The Editor:

Sir—I see you say in a brief notice of the book "Eclipse or Empire" that the authors "tell us of multitudinous inventions coming from other countries and blame us for not having invented these things ourselves. But on the one hand they do not seek for the causes of this universal distribution of inventive genius nor on the other hand do they suggest any remedy for Britain's alleged calamitous position."

Perhaps under the circumstances you would be good enough to reprint the following passage from "Eclipse or Empire" (p.129):

"It will be noted that, until other nations developed the scientific method in industry and affairs, we were the chief inventors and pioneers—that is, so long as all peoples relied upon the empirical method. The inference to be drawn is that the British race possessed the most inventive genius of all peoples. On the other hand, untrained and uninstructed, or rather with inferior training and instruction, it cannot rival other nations enjoying better educational advantages. The deduction is obvious. If we can bring ourselves as a nation to submit to the necessary mental training and to adopt the painstaking methods of the foreigner in research work, it is certain that we shall again lead the world. We possess scientists of as great or greater eminence than most other countries, but their abilities are more or less lost because they lack an appreciative audience—both in the Government and among the people generally."

This is, of course, only one among many passages in "Eclipse or Empire," which show clearly both why we have lost the lead in invention and how we can regain it. To make these things plain is one of the main objects of the book.

SAMUEL TURNER.

Rochdale, December 19.

SPECIAL·CORRESPONDENCE

JOHANNESBURG.

STATE MINING.—At the time of writing (December 2) the question of the Government establishing State mines to work the gold deposits of the Far East Rand is attracting considerable attention, and a Government Commission is busy taking evidence on the subject. It may be remembered that in January last, the Nationalist Party presented a petition in favour of State mining to Parliament, on the grounds that it would find work for thousands of whites and natives, and prove of immense financial advantage to the State. Since that date the Labour party and others have been working on the same lines, with the result that the Government considered it expedient to appoint a Commission to investigate the subject. During the last month the question of State mines has well nigh monopolized attention in mining circles here.

Those opposed to State mining admit that there exists no sound reason why the Government should not be able to command the services of equally competent persons to conduct the mining operations, providing equal remuneration was paid for such services, but that seems opposed to Government methods. They also point out that it is an undoubted fact that there does not exist the same desire for efficiency in Government service as in private enterprise. It was stated in evidence, by witnesses who knew something about State mining in other countries, that State mines were over-staffed, and subject to all kinds of political jobbery. Even nowadays the Government administration comes in for severe criticism, and if mining was added to its other undertakings, its position might become unbearable. We have it on the authority of the Minister of Mines at the time the petition in favour of State mining was presented, that the Government was not desirous of taking on their shoulders the responsibility and risks of mining. It is only necessary to refer to the annual report of the Government auditor to discern the drawbacks the State would suffer by undertaking State mining. Probably the existing Government departments are as free from abuses as it is possible to make them; even then glaring instances of abuse occasionally come to light. If mining with all its various branches of temptation were taken in hand by the State, there would be less scruple shown in the mine as well as in the mill, and with the State mines losing from so many quarters, the profits would fall below those earned by private enterprise. These are some of the principal objections urged against State mining, without mentioning the strong inducement that would exist for experimenting with white labour, and turning the mines into a huge charity organization.

Other witnesses before the Commission pointed out that mining in the Far East Rand was a risky business, as were instanced the results at Van Dyk, Rand Collieries, Rand Klipfontein, and other mines. In fact if the whole area be considered from Boksburg to beyond Springs to the actual outcrop of the reef there have been as many blanks as prizes drawn. Under these circumstances many witnesses urged that unless private enterprise refused to pay a fair price for the mining rights, the Government would not be justified in taking up these areas to work as State mines.

On the other hand, many witnesses stated that there could be no objection to the Government working the Far East Rand areas as State mines, as in that case they would receive the whole of the profits, in place of a small proportion as proposed. Spread over the whole of the Far East Rand, the risks would not be any greater for the Government than for the capitalist. They could see no reason why, if a competent Mining Board was appointed to control the whole of the operations, the Government should not be able to work the areas as cheaply and efficiently as private enterprise. Another advantage would be that the Government would be able to obtain the necessary capital on much better terms than private enterprise. The extra profits produced by State mining could also be made available for the promotion of agriculture and local industries.

There is one aspect of the question which has not been fully dealt with, and that is the duty of the Government as owner of these areas to do everything in its power to bring about the quick development and working of these areas. One witness pointed out that while the gold was allowed to remain in the ground, there was a great loss of interest, through the gold not being in circulation, while Professor Lehfeldt urged that there was already a glut of gold, and the more gold the mines turned out the less its value would be. It is clear that the Government will benefit more by the working of these areas than any one else, whether it is by State mines or private enterprise, and it is therefore the duty of the Government to do all in its power to encourage the working thereof. As owner of the gold in the areas, a certain amount of responsibility rests upon the Government, and even if it came to proving the value of the doubtful portions, of which there is a considerable area, that is not too much to ask of the Government. At all events it would be easy for the Government, when granting these leases to private owners, to make such provisions as would enable the value of the neighbouring areas to be ascertained, either by examination underground, or if it became necessary by actual driving of prospecting roads on behalf of the Government. At depths of from 4,000 ft. to 5,000 ft. this is a matter worthy of some consideration.

HEIDELBERG DISTRICT.—The Heidelberg district has always proved an irresistible attraction for speculation, and its reefs difficult to identify. It was in this district that the Coronation fiasco occurred, which ought never to have happened had a competent geologist been called in to advise.

Attempts are again being made to attract attention to the district, under the guise that it is part of the popular Far East Rand goldfield. From a geological standpoint this is perfectly true, but of all the unproved portions of the Far East Rand, the Heidelberg district will have the least chance of success. A company called the Southern Van Ryn Co. has just started its fifth bore-hole in search of a payable reef near the Nigel. Judging from the official reading of the cores of the No. 4 bore-hole put down by this syndicate, the geology of those in charge of the bore-holes seems somewhat mixed. We were under the impression that it had long ago been decided beyond question that the Van Ryn and the Nigel reefs were contemporaneous and the same reefs, a view confirmed by Dr. Mellor, of the Geological Survey. In No. 4 bore-hole put down by the Southern Van Ryn Co. near the Nigel, several reef leaders were passed through at a depth of 770 ft., and these were suggested at the time as containing the Van Ryn type of pebble. At a depth of 1,367 ft. in the same bore-hole, a series of leaders and quartzite bands 67 in. thick was passed through, and identified as similar to the New Rietfontein reef, and also to leaders being worked at the present time at the Van Ryn mine. At 1,490 ft. other reefs occur with a slate foot-wall which it is presumed is the Nigel reef. If this is the correct reading we have here the Van Ryn overlying the Rietfontein reef, also the Nigel, a new and impossible state of affairs.

At the annual meeting of the Southern Van Ryn company, attention was drawn to the low price of the shares and the meagre support afforded by the public to the scheme. The public can scarcely be expected to take the scheme seriously considering the geology upon which it is based, and if the company desires public support, the best way to deserve it would be to call in a geologist of repute to advise them. It does not necessarily follow that even then the public will come forward and support the scheme, even although it is situated in the Far East Rand. The Platkop Syndicate was not successful in raising the capital they asked for, though the property was reported upon by a geologist of repute, and though the neighbourhood for many years has had possibilities, and known to be well worth prospecting. It must be recognized that the Heidelberg district is out of favour with investors, the present state of affairs at the Nigel mine not tending to imbue speculators with confidence, and it will require sound geological reasons, backed up with rich discoveries, before the district can be expected to regain the confidence of the public.

SHAFT-SINKING RECORD.—What is believed to be a world's record in shaft-sinking has just occurred at the circular shaft now in course of sinking for ventilation purposes at the Crown Mines. It was only to be expected that sooner or later the shaft-sinking record would fall to the credit of a circular shaft on the Rand. This has happened at No. 14 shaft of the Crown Mines on what is known as Booysen's Reserve where 252 ft. was sunk in 31 days, being 18 ft. better than the previous record on the Rand. Hitherto all the record sinking has been attained in the Kimberley Slates on the Far East Rand which lend themselves to rapid sinking, but in the instance now under notice all the sinking was done in quartzite. This vertical shaft is expected to strike the reef at a depth somewhere in the neighbourhood of 4,500 ft. from the surface, so when completed it will be the deepest vertical shaft on the Rand.

COAL MINING.—The position of the coal-mining industry of South Africa seems at last to be moving in the right direction. Hitherto the output has been gradually increasing, while the selling prices have gradually decreased until the Transvaal became one of the few places in the world where coal could be purchased at 4s. per ton at the pit's mouth. Since June the price has increased from 4s. 4d. to 4s. 7d. per ton, and the output in September constitutes a record. This increase in price, although slight, was not obtained without some trouble, and to obtain it the Coalowners' Association had perforce to lose a portion of its contract for the supply of coal to the railways. Fortunately there is an unusual demand for bunkering coal at all the South African ports, so that the loss of railway sales has not been felt. At the non-associated collieries now largely supplying the railways the average selling price at the pit tops in September was only 4s. 2d. per ton. The September output of coal in the Transvaal constituted a record, and there is every prospect of the demand for South African coal increasing for some time to come.

CAMBORNE.

EAST POOL & AGAR takes pride of place in a review of events during 1916 by reason of the development of the Rogers lode. As already recorded, this development has disclosed a large body of ore between the 160 and 240 fm. levels, giving high values in tin and wolfram. With anything like average prices ruling for those minerals, a prosperous future for this undertaking is assured. The managers, however, have not been content to rest satisfied with the development of the Rogers lode, but have recently installed a Sullivan diamond-drilling plant. An operator was brought over specially from America to run the plant in the first instance, and to give instruction to local men. This drill has been installed at the 170 fm. level to locate the position of the Middle, Ginger Pop, and other lodes in the western section of East Pool. Diamond-drilling is not new in Cornwall, having been tried on several occasions, notably at Dolcoath and South Crofty, but for reasons which are not clear the work was discontinued. At East Pool a 10 ft. lode, showing promising values, has already been located by the drill. The report and accounts for 1916, which are shortly due, will doubtless be of such a character as will give general satisfaction to the shareholders. Already two interim dividends of 1s. per share have been paid on account of the profit earned last year. The production of tin concentrate for 1915 was 597 tons, realizing £53,042. For 1916, the quantity sold at the ticketing was 904 tons, realizing £93,468.

DOLCOATH has not had a good year, but the prospects at the close were distinctly encouraging. Shortage of labour has curtailed necessary developments, and made it quite out of the question to increase the output to meet the higher costs now ruling, while there has been some fall in the stoping values. The sales of black tin for 1915 amounted to 1,187 tons, and realized £110,908. Last year, the quantity ticketed was 1,064 tons, realizing £110,808. Fortunately, the fall in the quantity would appear to have been offset by the increase in the price realized. Recently, the Harriet lode series has been intersected in the Stray Park section of the property in the cross-cut north at the 238 fm. level. No official information is available as to the size and value of the lode, but it is common knowledge locally that the discovery is regarded as one of importance. This series of lodes was worked in another section of the property 15 years or so ago, and while not very rich, was fairly productive. It is understood that similar values would yield profitable results under present conditions. There has also been an improvement in the main lode in the bottom level, so it is anticipated that Capt. Arthur Thomas will at the meeting be able to make an encouraging statement.

SOUTH CROFTY.—There have been no important discoveries at this mine during the year just closed, but the developments appear to have disclosed ore of the average grade, and there are high hopes that 1917 will see the intersection of the Rogers lode, which has opened up so splendidly in the adjoining property. Cross-cuts are being put out north from Robinson's shaft in the direction of the North Crofty section of the property at the 180 and 225 fm. levels, and the former is expected to reach the lode during the next six months. A diamond-drill would probably have located it ere this. South Crofty is the steadiest producer in Cornwall, and this reflects great credit on the management, which has succeeded in earning handsome profits on a very low-grade complex ore. In 1915, the production of tin concentrate was 628 tons worth £59,440, with 98 tons of wolfram, and 660 tons of arsenic. The returns of wolfram and arsenic for 1916 are not available, but the ticketing papers disclose the fact that 583 tons of tin concentrate was sold realizing £60,965.

AT BASSET, the returns have been slightly increased in spite of shortage of labour and pumping troubles, and this increase has been due to the distinct improvement of the lode below the 310 fm. level. A large sum of money has been spent on development at and below this level, and the faith of the management has been rewarded, and will probably be increasingly so in the future, unless shortage of labour prevents the adequate opening up of this promising section of ground. The breakage of the large pumping engine at Pascoe's shaft seriously retarded the returns for some time, but a new engine was expeditiously installed. The output at Basset for many years has been totally inadequate when considered in proportion to the high pumping charges, but it is out of the question in these times to remedy this state of affairs. In 1915, 558 tons of tin concentrate was produced, and in 1916 the return was 567 tons.

TINCROFT.—There has been a fall in the returns of black tin, compared with the previous year, as judged by the sales at the ticketing, but probably higher prices for this and the by-products will compensate. In 1915, 609 tons of tin concentrate realized £53,883; in 1916, the approximate figures were 513 tons, realizing £51,500. The southern section of the Tincroft lode has been developed with a fair measure of success from the 208 fm. level, and but for this fact, a curtailment of output would probably have become necessary. A second magnetic separator has recently been installed to deal with the increasing quantities of wolfram found in the shallower levels.

THE GRENVILLE management will probably be glad to see the back of 1916, for it has been a bad year. The returns have been depressingly down, and no substantial amount of ground of average grade has been opened, although there are indications that some better values will be found below the 375 fm. level west of Fortescue's shaft when the 395 fm. level west has been driven sufficiently to reach this shoot. It is a pity that, when the mine was doing well some years ago, the shaft was not sunk and the lode developed well ahead of stoping requirements. Now, unfortunately, labour is not available to develop this ground vigorously. However, Grenville is a mine of surprises, and doubtless the confidence of the owners will be rewarded in due course. In 1915, the sales of black tin amounted to 613 tons with a value of £56,991; last year, the quantity ticketed was 471 tons, realizing £48,873.

LEVANT.—The accounts for the 16 weeks ended November 15 last showed a loss of £876, and a call of 5s. was made on the shares. This loss was due to machinery breakages. The tonnage milled was 5,837 tons, producing 114 tons of tin concentrate, or a recovery of 43 lb. per ton. In the previous 16 weeks, the tonnage handled was 7,309 tons of a similar grade, so that the effect of the reduction in output is obvious. It is evident that the shareholders should forego dividends for some time to come, and spend the money in overhauling the plant and on development.

ST. AGNES.—There has been a serious curtailment of mining operations in the St. Agnes district during the year. First, Wheal Kitty got into financial difficulties, owing to a fall in lode values and a shortage of labour; this was followed by the closing down of West Kitty a few weeks ago. The machinery on the latter property was recently sold to satisfy in part the debt due to the mineral owners for royalties, but one can only hope that money will yet be found to re-open this property. For years, it has been handicapped by a load of debt, but there can be no question that this, and the adjoining property of Wheal Kitty, would make a most attractive mining proposition. But for the conditions ruling at present, adequate capital would have been provided to operate the combined mines.

THE TIN TICKETINGS for 1916 reveal the fact that there has been a small reduction in sales compared with the previous year, as the following figures demonstrate: For 1915, 4,918 tons, value £448,362; for 1916, 4,668 tons, value £478,194.

PERSONAL

E. R. BAWDEN has resigned as manager of the Threlkeld mines, Cumberland, and is going to Nigeria.

JAMES P. BEST has been appointed mechanical engineer for Ropp Tin Limited, Nigeria.

E. C. BLOOMFIELD has obtained a commission in the Canadian Engineers.

F. O'D. BOURKE, manager for the Naraguta company, is here from Nigeria.

T. J. JONES is here from Siberia.

FREDERICK LAIST has succeeded E. P. Mathewson as manager of the metallurgical works at Anaconda.

C. G. LUSH has returned from Portugal.

W. T. MADGE is here from Siberia.

E. T. MCCARTHY has returned from Russia.

DEANE P. MITCHELL has returned from America.

ALFRED PEGLER has been appointed managing director of the Weardale Lead Company, Limited.

H. A. PIPER has returned from Rhodesia.

H. J. ROBERTSON, lately at the Abosso mine, West Africa, has left London for Australia.

ARTHUR J. RUSSELL has left for Colombia to visit the mine of the Tolima company.

SYDNEY A. R. SKERTCHLEY has been appointed consulting engineer to the San Antonio de Esquilache (Peru) Mines, Limited.

E. W. SPENCER is here from Tarkwa, West Africa.

WALLACE WILLIAMSON left on December 27 for the Mongu mine, Nigeria.

METAL MARKETS

COPPER.—Government regulations have had the intended effect of producing lower official quotations, and the standard market, which ruled at £151 cash and £143 three months at the beginning of December, had declined to £139 cash and £135 three months at the close. Electrolytic in the same period was reduced from £170 to £150 in this country, and from 34½c. to 31c. for early delivery in New York. Forward copper is offered at heavy discounts. The peace negotiations and the flurry on the New York stock market have furthered the downward movement, which is welcomed by every importing country, and which cannot, we believe, be adverse in the long run to the producing mines themselves. Trading during the month has been light, buyers in America being inclined to hold their hand with a declining market, while on this side they are for the most part supplied from Government purchases. The latest regulations emanating from the Ministry of Munitions forbid further private dealing in the metal, and all stocks held both of refined and unrefined copper are taken over on behalf of the department. There appears to be no shortage in America, where estimates of production indicate a plenitude of supplies. A further decline in the market there seems inevitable.

TIN.—The tone has been heavy, and the latest prices show a rather severe drop from those of the beginning of the month, when the quotations stood at £190. 7s. 6d. cash and £192. 7s. 6d. three months. £177 was quoted for cash at one time, but the close of the month witnessed a recovery to £178. 10s. for cash and £180. 12s. 6d. three months. Banka has been firmly held during the decline, and China has been out of the market, but sales from the Straits have been regular at round about the parity of the London standard market. English buying has been very quiet, only 40% of the tinplate mills being in operation, with certainty of further works being shut down. The American market has been the chief support, and reports are current of the operations of a syndicate in New York to control prices. English tin is in demand for export to Russia and the Mediterranean. Stocks in England are plentiful, so that Straits is being sold at about the parity of standard, and the contango looks like widening.

LEAD.—The official quotation still stands at £30. 10s.–£29. 10s., but there have been no public transactions. Supplies in private hands are exhausted, and the imports outside Government supplies are negligible. Freight from Spain continues exceedingly scarce, and consumers here, but for Government official assistance, would be cornered for raw material. As it is, they are drawing their immediate requirements from Government stocks.

SPELTER. — The market has been easier and America has been selling at prices more on a parity with London quotations. Official markings have come down from £59. 10s.–£58 to £51–£48, and the position is looked upon with some distrust. Arrivals from America, Japan, and Holland have been somewhat plentiful, but Japan has seen her way to reduce values in line with the market in this country.

NICKEL.—£225 per ton.

QUICKSILVER.—£18s. 10s. per flask of 75 lb.

SILVER.—The price has remained firm and steady during the past month between 36d. and 37d. per standard ounce.

We give no quotations for antimony, aluminium, platinum, bismuth, or cadmium ; and no quotation for any ore or concentrate.

PRICES OF CHEMICALS. January 9.

Owing to the war, buyers outside the controlled firms have a difficulty in securing supplies of many chemicals, and the prices they pay are often much higher than those quoted below.

		£	s.	d.
Acetic Acid, 40%	per cwt.	1	18	0
,, 60%	,,	2	16	0
,, Glacial	,,	6	10	0
Alum	per ton	14	0	0
Alumina, Sulphate of	,,	18	10	0
Ammonia, Anhydrous	per lb.		1	9
,, 0·880 solution	per ton	32	10	0
,, Chloride of, grey	per cwt.	1	18	0
,, ,, ,, pure	,,	3	10	0
,, Nitrate of	per ton	55	0	0
,, Phosphate of	,,	85	0	0
,, Sulphate of	,,	18	0	0
Arsenic, White	,,	41	0	0
Barium Chloride	,,	30	0	0
,, Carbonate	,,	9	0	0
,, Sulphate	,,	5	10	0
Bleaching Powder, 35% Cl.	,,	28	0	0
Borax	,,	33	0	0
Carbolic Acid, 60% Crude	per gal.		3	6
China Clay	per ton	1	10	0
Copper, Sulphate of	,,	65	0	0
Cyanide of Potassium, 98%	per lb.		1	0
,, ,, Sodium, 100%	,,			10
Hydrofluoric Acid	,,			6
Iodine	,,		14	0
Iron, Sulphate of	per ton	4	5	0
Lead, Acetate of, white	,,	85	0	0
,, Nitrate of	,,	65	0	0
,, Oxide of, Litharge	,,	42	0	0
,, White	,,	47	0	0
Magnesite, Calcined	,,	15	0	0
Magnesium Sulphate	,,	10	10	0
Oxalic Acid	per lb.		1	7
Phosphoric Acid	,,			10
Potassium Bichromate	,,		1	4
,, Carbonate	per ton	125	0	0
,, Chlorate	per lb.		2	4
,, Chloride, 80%	per ton	55	0	0
,, Hydrate (Caustic) 90%	,,	300	0	0
,, Nitrate	,,	65	0	0
,, Permanganate	per lb.		12	6
,, Prussiate, Yellow (Ferricyanide)	,,		4	0
,, Sulphate, 90%	per ton	60	0	0
Sodium Metal	per lb		1	3
,, Acetate	per ton	70	0	0
,, Bicarbonate	,,	6	15	0
,, Carbonate (Soda Ash)	,,	7	0	0
,, ,, (Crystals)	,,	3	5	0
,, Hydrate, 76%	,,	22	0	0
,, Hyposulphite	,,	13	0	0
,, Nitrate, 95%	,,	19	10	0
,, Phosphate	,,	30	0	0
,, Silicate	,,	7	0	0
,, Sulphate (Salt-cake)	,,	2	2	6
,, ,, (Glauber's Salts)	,,	3	10	0
,, Sulphide	,,	22	0	0
Sulphur, Roll	,,	19	0	0
,, Flowers	,,	19	0	0
Sulphuric Acid, non-arsenical 140°T.	,,	4	5	0
,, non-arsenical 95%	,,	7	0	0
Superphosphate of Lime, 18%	,,	5	10	0
Tin Crystals	per lb.		1	4
Zinc Chloride, solution 100°T.	per ton	25	0	0
Zinc Sulphate	,,	25	0	0

STATISTICS.

Production of Gold in the Transvaal.

	Rand	Elsewhere	Total	Value
	Oz.	Oz.	Oz.	£
Year 1912	8,753,563	370,731	9,124,299	38,757,560
Year 1913	8,430,998	363,826	8,794,824	37,358,040
Year 1914	8,033,567	344,570	8,378,139	35,588,075
Year 1915	8,772,919	320,752	9,073,671	38,627,461
January 1916	759,852	27,615	787,467	3,344,948
February	727,346	26,248	753,594	3,201,063
March	768,714	27,975	796,689	3,384,121
April	728,399	26,273	754,672	3,205,643
May	751,198	26,483	777,681	3,303,377
June	735,194	26,570	761,764	3,235,767
July	733,485	27,602	761,487	3,232,891
August	752,940	28,210	781,150	3,318,116
September	744,881	26,686	771,567	3,277,408
October	764,489	27,850	792,339	3,365,642
November	756,370	26,696	783,066	3,326,253

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
July 31, 1915	190,026	9,371	—	199,397
August 31	196,866	9,943	—	206 809
September 30	204,833	9,743	—	214,576
October 31	210,017	9,513	—	219,530
November 30	210,068	9,432	—	219,500
December 31	209,438	9,309	132	218,879
January 31, 1916	209,835	9,228	802	219,865
February 29	209,426	9,468	970	219,864
March 31	203,575	9,588	917	214,080
April 30	199,936	9,827	938	210,701
May 31	194,765	9,811	1,459	206,035
June 30	192,809	9,859	2,105	204,773
July 31	192,130	9,932	3,339	205,401
August 31	194,112	10,086	5,146	209,344
September 30	197,734	10,239	6,527	214,500
October 31	199,330	10,907	6,358	216,595
November 30	196,132	11,118	5,928	213,178

Cost and Profit on the Rand.

Compiled from official statistics published by the Transvaal Chamber of Mines. The profit available for dividends during 1915 was 63% of the working profit.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
Year 1912	25,486,361	29 2	19 3	9 11	12,678,095
Year 1913	25,628,432	27 9	17 11	9 6	12,189,105
Year 1914	25,701,954	26 6	17 1	9 0	11,553,697
Year 1915	28,314,539	26 3	17 5	8 5	11,931,062
January 1916	2,449,518	26 1	17 10	7 10	962,120
February	2,297,276	26 8	18 4	8 0	924,310
March	2,455,019	26 5	18 1	8 0	979,234
April	2,291,231	26 10	18 2	8 4	951,247
May	2,382,298	26 7	18 2	8 2	977,263
June	2,296,520	27 0	18 3	8 6	977,681
July	2,370,244	26 1	17 10	8 0	949,606
August	2,423,669	26 3	17 10	8 1	976,125
September	2,367,793	26 6	18 0	8 3	972,704
October	2,453,437	26 4	17 10	8 2	1,001,843

Production of Gold in Rhodesia and West Africa.

	Rhodesia.		West Africa.	
	1915	1916	1915	1916
	£	£	£	£
January	293,133	318,586	143,649	140,579
February	286,879	313,769	144,034	137,739
March	299,686	335,368	153,770	150,987
April	315,541	339,386	149,978	135,976
May	318,898	323,783	142,123	132,976
June	322,473	333,070	135,289	127,107
July	336,565	322,365	140,290	128,574
August	344,493	338,001	139,364	125,143
September	321,085	322,035	135,744	127,138
October	339,967	325,608	141,771	132,577
November	313,160	317,135	122,138	130,101
December	331,376	—	158,323	—
Total	3,823,166	3,589,116	1,706,473	1,468,897

Western Australian Gold Statistics.

	Reported for Export oz.	Delivered to Mint oz.	Total oz.	Total value £
January 1916	1,861	92,124	93,985	399,220
February	2,832	65,138	67,970	288,717
March	5,600	88,393	93,993	399,255
April	2,926	87,601	90,527	384,532
May	577	83,301	83,878	356,289
June	2,070	92,612	94,682	402,181
July	912	91,725	92,637	393,495
August	*	89,522	*	*
September	*	85,978	*	*
October	*	82,732	*	*
November	*	87,322	*	*
December	*	88,205	*	*

* By direction of the Federal Government the export figures will not be published until further notice.

Australian Gold Returns.

	Victoria.		Queensland.		New South Wales
	1915	1916	1915	1916	1916
	£	£	£	£	£
January	69,900	89,900	43,770	66,700	39,000
February	122,300	76,500	85,850	79,050	30,000
March	142,800	103,600	98,550	76,920	36,000
April	109,300	60,000	97,320	83,300	63,000
May	102,900	119,500	130,470	116,230	19,000
June	134,200	86,000	90,500	72,200	18,000
July	154,800	100,600	88,830	85,400	23,000
August	80,300	66,800	93,050	86,000	24,000
September	138,900	115,100	79,470	65,450	32,000
October	111,700	81,400	91,800	74,800	32,000
November	115,300	94,000	77,780	60,300	31,000
December	115,400	—	81,170	—	111,000
Total	1,397,800	993,400	1,078,560	866 950	459,000

Production of Gold in India.

	1913	1914	1915	1916
	£	£	£	£
January	187,910	193,140	201,255	192,150
February	179,981	185,508	195,970	183,264
March	189,715	191,853	194,350	186,475
April	191,215	189,197	196,747	192,208
May	190,607	193,031	199,786	193,604
June	189,322	192,224	197,447	192,469
July	193,859	195,137	197,056	191,404
August	193,998	196,560	197,984	192,784
September	191,642	195,843	195,952	192,330
October	194,314	198,191	195,531	191,502
November	192,606	197,699	192,714	192,298
December	201,931	211,911	204,590	205,164
Total	2,299,315	2,340,259	2,366,457	2,299,568

Daily London Metal Prices

Copper, Lead, Zinc, Tin, in £ per long ton. Silver in pence per standard ounce.

	Copper, Standard			Copper, Electrolytic	Lead			Zinc			Tin, Standard			Silver
Dec.	£	s.	d.	£	£	s.	d	£	s.	d.	£	s.	d	d.
12	145	10	0	168	30	10	0	57	0	0		*		36¾
13	142	10	0	164	30	10	0	57	0	0		*		36⅝
14	142	10	0	164	30	10	0	56	10	0		*		36⅝
15	142	10	0	164	30	10	0		*			*		37
18	142	10	0	164	30	10	0		*			*		36 13/16
19	142	10	0	161	30	10	0		*			*		36 13/16
20	142	10	0	160	30	10	0		*			*		36 13/16
21	142	10	0	155	30	10	0		*			*		36 13/16
22	141	10	0	154	30	10	0		*			*		36 11/16
27	140	10	0	152	30	10	0	51	10	0	175	15	0	36½
28	139	10	0	151	30	10	0	51	0	0	176	15	0	36½
29	138	10	0	150	30	10	0	51	0	0	178	5	0	36½
Jan.														
2	133	10	0	145	30	10	0	50	5	0	182	0	0	36½
3	133	10	0	145	30	10	0	50	10	0	181	15	0	36½
4	133	10	0	145	30	10	0	50	10	0	180	15	0	36½
5	130	0	0	144	30	10	0	50	10	0	180	15	0	36½
8	133	0	0	143	30	10	0	50	5	0	181	10	0	36⅜
9	133	0	0	143	30	10	0	50	5	0	181	5	0	36¼
10	131	0	0	141	30	10	0	49	10	0	181	15	0	36¼

* No quotations published.

Imports of Ores and Metals into United Kingdom.

These figures do not include Government imports.

Long tons.

	Year 1915	Nov. 1916	Dec. 1916	Year 1916
	Tons	Tons	Tons	Tons
Copper Ore	38,131	2,396	3,386	34,492
,, Matte and Precipitate	38,372	4,574	2,178	43,839
,, Metal	180,368	8,616	9,076	111,412
Copper and Iron Pyrite	903,401	55,956	70,750	951,206
Tin Concentrate	44,748	1,792	1,849	33,912
,, Metal	38,896	3,402	1,632	33,646
Manganese Ore	377,324	32,850	19,905	439,509
Lead, Pig and Sheet	256,476	8,206	19,024	157,985
Zinc (spelter)	74,520	5,573	5,519	53,324
	lb.	lb.	lb.	lb.
Quicksilver	3,043,434	54,001	1,800	2,556,214

Stocks of Copper.

Reported by Henry R. Merton & Co. Ld. Long tons

	Oct. 31 1916	Nov. 30, 1916	Dec. 31, 1916
	Tons	Tons	
Standard Copper in England	771	520	Not Published.
Fine Copper in England	2,397	4,958	
,, ,, Havre	2,290	2,123	
,, ,, Afloat from Chile	650	200	
,, ,, ,, from Australia	4,000	4,000	
Total Visible Supply	10,108	11,801	
Fine Copper in Rotterdam	1,150	1,150	
,, ,, Hamburg	2,867*	2,867*	
,, ,, Bremen	1,106*	1,106*	

* As on July 31, 1914, but presumably present stock nil.

Exports of Copper from United States

Reported by United States Customs.

1915	Long tons	1916	Long tons	1916	Long tons
July	16,812	January	21,863	July	35,048
August	16,289	February	20,548	August	34,700
September	14,327	March	24,006	September	28,572
October	26,153	April	19,980	October	32,712
November	19,396	May	14,700	November	21,433
December	32,936	June	38,277	December	21,438
Total 1915	257,915			Total 1916	313,277

Stocks of Tin.

Reported by A. Strauss & Co. Long tons.

	Oct. 31, 1916	Nov. 30, 1916	Dec. 31, 1916
	Tons	Tons	Tons
Straits and Australian, Spot	2,201	2,014	1,990
Ditto, Landing and in Transit	657	1,648	750
Other Standard, Spot and Landing	887	1,048	1,550
Straits, Afloat	3,405	2,282	4,177
Australian, Afloat	225	250	330
Banca, on Warrants	—	—	—
Ditto, Afloat	1,904	3,934	2,578
Billiton, Spot	—	—	—
Ditto, Afloat	290	792	533
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	1,400*	673*	968*
Afloat for United States	4,433	6,260	4,698
Stock in America	3,419	2,850	3,511
Total Stock	18,821	21,751	21,085

* Including 200 tons on board enemy's ships either captured or lying in neutral ports

Shipments and Imports of Tin

Reported by A. Strauss & Co. Long tons.

	Year 1915	Nov. 1916	Dec. 1916	Total, 1916
	Tons	Tons	Tons	Tons
Shipments from:				
Straits to U.K.	23,330	1,407	2,870	27,157
Straits to America	31,565	3,475	1,265	25,943
Straits to Continent	11,024	498	623	8,487
Australia to U.K.	2,481	315	200	2,537
U.K., Holland, and Continent to America	14,967	1,050	1,025	14,863
Imports of China Tin into U.K. and America	3,012	—	15	1,305
Imports of Bolivian Tin into Europe	22,591	1,225	629	15,116

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

	1912	1913	1914	1915	1916
	Tons	Tons	Tons	Tons	Tons
January	204	466	485	417	531
February	240	427	469	358	528
March	247	510	502	418	547
April	141	430	482	444	486
May	144	360	480	357	536
June	121	321	460	373	510
July	140	357	432	455	506
August	201	406	228	438	498
September	196	422	289	442	535
October	256	480	272	511	584
November	340	446	283	467	679
December	310	478	326	533	—
Total	2,540	5,103	4,708	5,213	5,940

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters.

Long Tons.

	1912	1913	1914	1915	1916
	Tons	Tons	Tons	Tons	Tons
January	4,022	4,121	4,983	4,395	4,316
February	4,318	3,823	3,555	3,780	3,372
March	3,196	3,562	3,839	3,653	3,696
April	3,904	4,066	4,087	3,619	3,177
May	4,277	4,319	4,135	3,823	3,729
June	3,472	3,993	4,303	4,048	3,435
July	4,234	4,245	4,582	3,544	3,517
August	4,454	4,620	3,591	4,046	3,732
September	4,115	4,379	3,623	3,932	3,636
October	3,905	4,409	3,908	3,797	3,681
November	4,112	3,976	4,085	4,059	3,635
December	4,241	4,614	4,351	4,071	3,945
	48,250	50,127	49,042	46,767	43,871

Sale of Tin Concentrate at Redruth Ticketings.

	Long tons	Value	Average
Year 1915	4,918	£448,362	£90 14 6
January 3, 1916	157	£14,934	£95 2 6
January 17	186¼	£18,122	£97 6 1
January 31	181	£18,023	£99 11 7
February 14	179¼	£18,343	£102 6 7
February 28	181	£18,882	£104 6 5
March 13	182	£19,921	£109 9 2
March 27	190½	£21,437	£112 10 6
April 10	185½	£21,517	£115 19 11
April 25	164	£18,504	£112 16 7
May 8	181	£20,852	£115 4 2
May 22	190	£20,986	£110 9 0
June 5	175	£18,286	£104 9 10
June 19	182	£18,204	£100 0 6
July 3	179	£17,477	£97 12 10
July 17	186½	£17,114	£91 15 4
July 31	172¼	£16,172	£93 17 8
August 14	166	£15,955	£96 2 4
August 28	180¼	£17,345	£96 4 8
September 11	184	£17,113	£93 0 2
September 25	166½	£15,980	£95 19 7
October 9	197	£19,443	£98 13 11
October 23	170	£17,167	£100 19 9
November 8	194½	£19,701	£101 5 10
November 20	172	£18,044	£104 18 2
December 4	160½	£16,588	£105 4 6
December 18	156¼	*	*
Total, 1916	4,668	£478,194	
January 2, 1917	176		

* Prices not published.

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	Jan. 5, 1916 £ s. d.	Jan. 5, 1917 £ s. d.
RAND:		
Bantjes	7 6	11 6
Brakpan	3 8 9	4 17 6
Central Mining (£8)	6 8 9	6 18 9
Cinderella	4 9	5 0
City & Suburban (£4)	2 2 6	1 17 6
City Deep	3 13 9	4 5 0
Consolidated Gold Fields	1 8 0	1 10 0
Consolidated Langlaagte	1 18 9	1 8 0
Consolidated Main Reef	1 0 3	18 0
Consolidated Mines Selection (10s).	14 6	1 1 9
Crown Mines (10s.)	3 2 6	3 0 0
Daggafontein	9 6	14 0
D. Roodepoort Deep	13 9	1 3
East Rand Proprietary	1 1 3	12 3
Ferreira Deep	1 17 6	1 2 6
Geduld	1 17 3	2 4 0
Geldenhuis Deep	1 0 6	1 3 9
Gov't Gold Mining Areas	1 11 3	2 13 0
Heriot	3 0 0	2 12 6
Jupiter	6 9	8 0
Kleinfontein	1 11 3	1 5 0
Knight Central	11 3	10 0
Knight's Deep	1 8 9	1 6 3
Langlaagte Estate	19 6	18 0
Luipaard's Vlei	8 9	8 3
Main Reef West	6 0	4 6
Meyer & Charlton	5 19 6	5 11 3
Modderfontein (£4)	16 0 0	9 0 0
Modderfontein B	5 18 9	7 12 6
Modder Deep	5 11 3	7 6 3
Nourse	18 0	1 1 6
Rand Mines (5s.)	4 3 9	3 13 9
Rand Selection Corporation	2 15 6	3 11 3
Randfontein Central	10 0	13 3
Robinson (£5)	1 6 3	18 0
Robinson Deep	1 3 9	1 15 0
Rose Deep	1 11 3	1 1 6
Simmer & Jack	9 6	7 0
Simmer Deep	2 3	4 6
Springs	1 18 0	3 1 6
Van Ryn	2 10 0	2 0 0
Van Ryn Deep	3 0 6	3 10 0
Village Deep	1 5 0	1 9 6
Village Main Reef	1 0 0	16 3
Witwatersrand (Knight's)	2 17 6	2 13 9
Witwatersrand Deep	1 7 6	1 1 6
Wolhuter	11 0	9 6
OTHER TRANSVAAL GOLD MINES:		
Glynn's Lydenburg	9 0	16 3
Sheba (5s.)	2 9	1 9
Transvaal Gold Mining Estates	1 4 6	1 0 6
DIAMONDS IN SOUTH AFRICA:		
De Beers Deferred (£2 10s.)	11 5 0	13 2 6
Jagersfontein	3 1 3	4 6 3
Premier Defer'd (2s. 6d.)	5 0 0	7 5 0
RHODESIA:		
Cam & Motor	14 6	9 6
Chartered British South African	11 0	12 0
Eldorado	11 6	9 3
Enterprise	5 0	5 0
Falcon	8 3	15 9
Giant	6 0	6 0
Globe & Phœnix (5s.)	1 6 6	1 17 0
Lonely Reef	1 5 6	1 4 6
Shamva	1 16 3	1 4 6
Wanderer (3s.)	1 3	1 9
Willoughby's (10s.)	5 0	4 6
WEST AFRICA:		
Abbontiakoon (10s.)	7 3	5 0
Abosso	9 0	8 6
Ashanti (4s.)	18 0	18 9
Prestea Block A	8 6	7 0
Taquah	15 6	17 0
WEST AUSTRALIA:		
Associated Gold Mines	6 0	4 0
Associated Northern Blocks	5 0	3 0
Bullfinch	6 0	2 6
Golden Horse-Shoe (£5)	1 17 6	1 14 6
Great Boulder Proprietary (2s.)	15 0	11 3
Great Boulder Perseverance	1 0	1 0
Great Fingall (10s).	1 9	1 0
Ivanhoe (£5)	2 5 6	2 2 6
Kalgurli	16 3	10 6
Sons of Gwalia	15 6	13 9

GOLD, SILVER, *cont.*	Jan. 5, 1916 £ s. d.	Jan. 5, 1917 £ s. d.
OTHERS IN AUSTRALASIA:		
Mount Boppy, New South Wales	13 9	7 6
Talisman, New Zealand	15 6	7 6
Waihi, New Zealand	1 15 0	1 14 6
Waihi Grand Junction, New Z'lnd	19 0	0 16
AMERICA:		
Alaska Treadwell (£5), Alaska	7 7 6	2 12 6
Buena Tierra, Mexico	15 0	12 6
Camp Bird, Colorado	7 0	6 0
Canadian Mining, Ontario	11 6	12 0
Casey Cobalt, Ontario	4 6	4 9
El Oro, Mexico	9 0	7 6
Esperanza, Mexico	11 0	8 9
Frontino & Bolivia, Colombia	9 0	13 6
Le Roi No. 2 (£5), British Columbia	10 9	9 6
Mexico Mines of El Oro, Mexico	4 0 0	3 12 6
Oroville Dredging, California	11 0	16 0
Plymouth Consolidated, California	18 6	1 0 0
St. John del Rey, Brazil	14 6	16 9
Santa Gertrudis, Mexico	9 9	8 9
Tomboy, Colorado	1 3 6	1 0 9
RUSSIA:		
Lena Goldfields	1 8 9	1 15 0
Orsk Priority	14 6	1 0 0
INDIA:		
Champion Reef (2s. 6d.)	9 3	5 9
Mysore (10s.)	3 18 9	3 5 0
Nundydroog (10s.)	1 5 6	1 5 6
Ooregum (10s.)	1 3 0	19 9

COPPER:	Jan. 5, 1916 £ s. d.	Jan. 5, 1917 £ s. d.
Anaconda (£10), Montana	18 15 0	18 0 0
Arizona Copper (5s.), Arizona	1 10 0	2 6 3
Cape Copper (£2), Cape Province	2 10 0	4 0 0
Chillagoe (10s.), Queensland	6	3
Cordoba (5s.), Spain	3 9	4 0
Great Cobar (£5), N.S.W.	2 6	2 0
Hampden Cloncurry, Queensland	1 9 6	1 14 6
Kyshtim, Russia	1 16 3	2 5 0
Messina (5s.), Transvaal	12 0	10 0
Mount Elliott (£5), Queensland	2 11 3	5 15 0
Mount Lyell, Tasmania	1 4 3	1 5 0
Mount Morgan, Queensland	1 18 9	1 12 6
Rio Tinto (£5), Spain	57 5 0	62 15 0
Sissert, Russia	1 0 0	1 5 6
Spassky, Russia	1 15 0	1 17 6
Tanalyk, Russia	1 11 3	2 8 9
Tanganyika, Congo and Rhodesia	1 15 6	2 [illegible] 9

LEAD-ZINC:	Jan. 5, 1916 £ s. d.	Jan. 5, 1917 £ s. d.
BROKEN HILL:		
Amalgamated Zinc	1 7 0	1 11 6
British Broken Hill	1 3 6	1 5 6
Broken Hill Proprietary (8s.)	2 10 0	2 11 6
Broken Hill Block 10 (£10)	1 0 0	1 0 0
Broken Hill North	2 3 6	2 4 0
Broken Hill South	7 0 0	8 8 9
Sulphide Corporation (15s.)	1 3 6	1 8 9
Zinc Corporation (10s.)	1 3 3	14 9
ASIA:		
Burma Corporation	1 12 6	3 18 0
Irtysh Corporation	1 13 9	2 5 6
Russian Mining	15 0	17 6
Russo-Asiatic	4 8 9	5 11 3

TIN:	Jan. 5, 1916 £ s. d.	Jan. 5, 1917 £ s. d.
Aramayo Francke, Bolivia	1 6 3	1 7 6
Bisichi, Nigeria	6 0	10 6
Briseis, Tasmania	4 9	4 6
Dolcoath, Cornwall	6 0	10 0
East Pool, Cornwall	7 6	1 11 3
Ex-Lands Nigeria (2s.), Nigeria	1 0	1 6
Geevor (10s.) Nigeria	—	8 9
Gopeng, Malay	1 10 0	1 8 9
Ipoh Dredging, Malay	13 9	16 3
Malayan Tin Dredging, Malay	1 10 0	1 17 6
Mongu (10s.), Nigeria	8 9	9 0
Naraguta, Nigeria	10 0	14 6
N. Nigeria Bauchi (10s.), Nigeria	1 6	2 9
Pahang Consolidated (5s.), Malay.	8 0	10 0
Rayfield, Nigeria	4 0	6 6
Renong Dredging, Siam	1 11 3	2 2 6
Ropp (4s.), Nigeria	13 0	16 3
Siamese Tin, Siam	2 15 0	2 10 0
South Crofty (5s.), Cornwall	6 6	15 6
Tekka, Malay	2 15 0	3 2 6
Tekka-Taiping, Malay	2 0 0	3 1 3
Tronoh, Malay	1 8 9	1 8 0

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also reviews of new books, and abstracts of the yearly reports of mining companies.

THE UDI-OKWOGA COALFIELD, NIGERIA.

Much has been heard during the past year or so of the new coalfield in Southern Nigeria, through which the railway from Port Harcourt to the interior to connect with the present railway at Naraguta will pass. Beyond brief references at the meetings of Nigerian tin companies, little or nothing has been said of this coal deposit. An article on the subject appearing in the *Bulletin* of the Imperial Institute for July–September 1916, published in the middle of December, will therefore be of particular interest.

The article describes the work of the Mineral Survey which was instituted in 1903 to examine the mineral resources of Southern Nigeria. The first important result obtained by this Survey was the discovery of lignite deposits on both sides of the Niger near Asaba, but this discovery was quite eclipsed by the finding of a great coalfield between Udi and Okwoga. The position of these two villages is shown on the accompanying map. The total area of the coalfield as at present determined is about 1,800 square miles. The existence of coal in this area was first noted by the surveyors, Messrs. A. E. Kitson and E. O. Thiele, in 1909, and the work of determining the area of the field by the observation of outcrops, and later by boring trials, was continued by these officers and by their successors, Messrs. A. D. Lumb and M. Whitworth, until the close of the survey in 1913. As the Government of Nigeria is the chief consumer of coal in the country for the use of the Government railways, the development of the coalfield has been undertaken by the Public Works Department.

The youngest rocks of the Udi region are loose detrital sediments consisting of reddish sands. These occur at the surface, are very variable in thickness, and are regarded as belonging to the Benin Sand series, which is of comparatively late Tertiary age. These superficial sands lie unconformably on Cretaceous strata, which are made up chiefly of sandstones, shales,

and mudstones. It is in these Cretaceous beds that the coal seams are found. The Cretaceous strata extend over a plateau for a distance of 80 miles, stretching northward from the Udi district to the Okwoga district. The plateau surface rises somewhat toward the north, and attains a height of over 2,000 ft. It slopes gradually to the west, and is not more than 200 ft. or so in height along the Oji river. The plateau is bounded on the east by a scarp in which outcrops of coal are found. A line of outcrops stretches along this escarpment northwards from near the source of the Mamu river, south of Udi, to Otukpa northwest of Okwoga.

The Cretaceous beds are almost horizontal. On the whole there is a slight westerly dip, so that to the west of the above-mentioned scarp the coal occurs at some depth from the surface. A boring made at a locality to the west of Udi and 32 miles from Onitsha revealed two seams of coal at depths of 40½ ft. and 82½ ft. respectively. In another boring still farther west, and 17 miles east of Onitsha, coal was found at a depth of 115 ft. Farther north coal outcrops have been observed as far west as the Iyokolla river, which is a few miles east of Ogrugru, and near the Anambra river.

The Udi coal is of the sub-bituminous type, and usually of a dull-black appearance, though some of the seams show alternating bands of dull and more lustrous coal. The specific gravity varies, and for material not containing more than about 15% of ash the value ranges from abont 1·16 to 1·32, with an average of about 1·23. As a rule the coal is fairly free from mineral impurity, but occasionally it contains nests and films of amorphous clayey matter and pyrite. Films and patches of chalybite and kaolinite occur as fillings of the joint cracks and small crevices in the coal. The coal ignites readily, and burns with a bright, steady flame, giving off only a small amount of smoke. It does not cake or decrepitate on heating. The ash is usually white or light grey, and practically free from clinker.

An analysis of a typical specimen of the coal taken from the 5 ft. seam now being developed gave the following results :

	%
Fixed carbon	48·41
Volatile matter	38·18
Ash	7·79
Moisture	5·62
Total	100·00
Sulphur	0·76
Calorific value in small calories	6,969

The localities in which coal seams are known to occur can be conveniently grouped as follows : (1) Udi district, (2) Okwoga district, (3) Idah and western Okwoga districts, (4) Awka and western Udi districts.

In the Udi district the coal seams are well exposed in the ravines that cut through the escarpment forming the eastern limit of the plateau. During the course of the Mineral Survey six distinct seams were found in this district, ranging from 2 in. to 5 ft, 8 in. in thickness. In the Udi neighbourhood there are four seams that reach a thickness of over 2 ft. The composition of the coals of the more important seams in this neighbourhood may be indicated by the following proximate analyses of two Udi specimens :

	Ofam River. 2 ft. seam. %	Stream behind Hausa barracks. 2 ft. 4 in. %
Fixed carbon	42·30	48·20
Volatile matter	33·82	38·34
Ash	18·42	8·45
Moisture	5·46	5·01
Total	100·00	100·00
Sulphur	0·74	1·16
Calorific value in small calories	5,976	6,913

Farther north numerous outcrops are seen in the sections exposed along the various rivers and their tributaries, notably the Atava, Nyaba, Olawba, Nyo, Azata, Obweti, Alia, Ekulu Abor, and Iyoku rivers. This is the most important of the coal areas known at present in Nigeria, since it contains the thickest seam, which has a thickness of 5 ft. in the Azata river exposure, and increases in thickness to 5 ft. 8 in. in the Obweti river exposure, where it is now being developed.

The following are analyses of samples obtained from this seam in various tributaries of the Obweti river :

	Iyocha Stream. 5 ft. 5 in. seam. %	Iyuguwene Stream. 5 ft. 4 in. seam. %	Iyube Stream. 5 ft. 8 in. seam. %
Fixed carbon	44·88	49·70	48·18
Volatile matter	35·60	36·83	37·36
Ash	14·89	7·61	7·42
Moisture	4·63	5·86	7·04
Totals	100·00	100·00	100·00
Sulphur	0·73	0·67	1·15
Calorific value in small calories	6,437	6,940	6,580

A sample of coal obtained more recently from the seam now being opened up, and stated to have been taken 100 ft. from the surface, presumably where the adit is being driven, gave the following analysis :

	%
Fixed carbon	54·21
Volatile matter	34·30
Ash	4·35
Moisture	7·14
Total	100·00
Sulphur	0·50
Calorific value in small calories	7,368

This sample consisted of black compact coal of good quality. The analysis shows that it approximates more closely to the ordinary bituminous type of coal than do samples from the Udi field previously examined. The coal did not cake on burning, and it gave a pale buff ash.

An examination of a large number of samples of coal collected in the Udi district shows that the coal is fairly uniform in quality, and this is particularly true of the thick seam in the Obweti river exposures, as shown by the analyses. A large number of samples from the Udi district as a whole showed extreme calorific values of 5,437 and 7,456, with an average of about 6,500. A number of samples from the main seam in the Obweti area showed extreme calorific values of 6,134 and 7,107, with an average of about 6,670.

As regards the Okwoga district, in the south part lumps of transported coal were found by the Mineral Survey in the Unwelli district. Proceeding northeastward from this locality, outcrops of coal were found to the southwest of Okwoga in the Apalla, Iyocha, and Afafa rivers. Analyses of samples from these localities gave the following results :

	Apalla River. 3 ft. 3 in. seam. %	Iyocha River. 3 ft. 2 in. seam. %	Afafa River. 1 ft. 4 in. seam. %	Afafa River. 4 ft. 9 in. seam. %
Fixed carbon	39·62	29·29	43·56	43·47
Volatile matter	43·77	39·55	35·82	37·59
Ash	4·60	21·26	8·59	8·13
Moisture	12·01	9·90	12·03	10·81
Totals	100·00	100·00	100·00	100·00
Sulphur	0·89	0·67	0·49	1·13
Calorific value in small calories	6,552	5,215	5,912	6,131
Specific gravity	1·3	1·4	1·3	1·3

All four samples consisted of black, sub-bituminous coal, and, excepting the Iyocha river sample, in which the percentage of ash was rather high, they represented coals of fairly good quality.

Farther north still, and lying to the west of Okwoga, coal outcrops were found near Orukuram and at Otukpa. The two seams occurring between Orukuram and Okwoga are in the Iyikor and Inimini rivers, and are 1 ft. 5 in. and 2 ft. thick respectively. The seam occurring at Otukpa, to the northwest of Okwoga, is in the Iyorba stream and is 3 ft. 11 in. thick. Samples from these three seams gave the following results on analysis:

	Iyikor River. near Orukuram. 1 ft. 5 in. seam. %	Inimini River. 2 ft. seam. %	Iyorba Stream. 3 ft. 11 in. seam. %
Fixed carbon	41·42	43·31	39·49
Volatile matter	37·41	34·26	34·96
Ash	11·64	10·07	14·05
Moisture	9·53	12·36	11·50
Totals	100·00	100·00	100·00
Sulphur	0·54	0·62	0·73
Calorific value in small calories	5,936	5,630	5,494
Specific gravity	1·25	1·30	1·35

The samples were rather friable as compared with typical Udi coal, but the results of analysis show that, from the standpoint of calorific value and chemical composition, they are of moderately good quality.

The Idah and Western Okwoga districts are to the west of Okwoga, and near the western boundary of the Okwoga district. Here outcrops of coal were found at the Aluma Spring, Enugu (10 in. seam), at Iyobo Spring, Obimo (3 ft. 6 in. seam), and the Iyokolla River, between Upabi and Adani, a few miles east of Ogrugru (1 ft. 8 in. seam). Another outcrop was found 3 miles southeast of Angba (6 in. seam) in the Idah district. Samples of these coals gave the following results on analysis:

	Aluma Spring 0 in. seam. %	Iyobo Spring. Obimo. 3 ft. 6 in. seam. %	Iyokolla River. 1 ft. 8 in. seam. %	South-east of Angba. 6 in. seam. %
Fixed carbon	36·88	18·52	44·61	10·65
Volatile matter	34·36	24·85	34·59	18·13
Ash	19·29	50·09	15·06	68·75
Moisture	9·47	6·54	5·74	2·47
Total	100·00	100·00	100·00	100·00
Sulphur	5·62	0·90	0·76	1·32
Calorific value in small calories	5,269	2,428	6,299	2,058
Specific gravity	1·28–1·48	1·7	1·3	1·71–2·28

The Iyokolla river sample consisted of dull-black sub-bituminous coal of moderately good quality, though the percentage of ash was rather high. The still higher percentage of ash in the Aluma Spring sample, together with the high percentage of sulphur, renders it of poor quality, while the other two samples represent material of little or no value as fuel, owing to their shaly character and consequent high percentage of ash.

The outcrop at Iyokolla river, which is a few miles east of Ogrugru and is near the Anambra river, is of special interest as being the most westerly outcrop found in the northern area. The position of this occurrence is 45 miles in a direct line west of the outcrop at Otukpa to the northwest of Okwoga.

The Awka and Western Udi districts are to the west of Udi. Investigations were made to ascertain by boring whether coal of the Udi type occurred within easy reach of Onitsha. Eight holes were drilled in the neighbourhood of Onitsha, to an average depth of 200 ft. A 4 in. seam of black and apparently sub-bituminous coal was struck at Nofia, 17 miles east of Onitsha, at a depth of 115 ft., but the amount obtained was too small for analysis. Coal was next found at a distance of 32 miles from Onitsha, two seams being struck at Oha Obenagu in the west of the Udi district, namely, a 3 ft. 10 in. seam at a depth of 40½ ft. and a 2 ft. 3 in. seam at 82½ ft. The bore-hole was continued to 190 ft., but no further seam was encountered. The samples obtained at Oha Obenagu consisted of black sub-bituminous coal, and gave the following results on analysis:

	3 ft. 10 in. seam. %	2 ft. 3 in. seam. %
Fixed carbon	50·46	36·06
Volatile matter	34·54	29·13
Ash	7·35	29·10
Moisture	7·65	5·71
Totals	100·00	100·00
Sulphur	2·60	1·24
Calorific value in small calories	6,801	5,114

These results indicate that the material from the 3 ft. 10 in. seam is of good quality as a fuel in most respects, but its sulphur percentage is rather high; whereas the material from the 2 ft. 3 in. seam is of comparatively poor quality owing to the high percentage of ash.

At a distance of 34 miles from Onitsha, near the Oji river, three seams were struck, namely a 6 in. seam at 19 ft., a 1 ft. 1 in. seam at 39 ft., and a 1 ft. 6 in. seam at 51½ ft. The specimens obtained, however, were too small for analysis, and the boring was stopped at 272 ft. Both here and at Oha Obenagu a strong flow of artesian water was reached at a depth of about 90 ft.

In addition to the drilling operations in this district, the Surveyors carried on surface prospecting as far as possible. A 4 in. seam, previously located at Obinoffia, was found to widen out to 1 ft. 6 in. on being traced northward, and the following seams were also located: (1) a 2 ft. seam at Achallowa; (2) a 1 ft. 2 in. seam between Achallowa and Amandim; (3) a 3 ft. 2 in. seam in the Oba river near Oha Obenagu; this is the same as the 3 ft. 10 in. stream struck in the bore-hole half a mile to the east.

Samples from these seams gave the following results on analysis:

	Achallowa. 2 ft seam. %	Between Achallowa and Amandim. 1 ft. 2 in. seam. %	Oba River. 3 ft. 2 in. seam %
Fixed carbon	24·73	37·18	48·84
Volatile matter	28·38	34·52	35·26
Ash	42·56	20·10	7·86
Moisture	4·33	8·20	8·04
Totals	100·00	100·00	100·00
Sulphur	0·81	1·54	2·44
Calorific value in small calories	3,982	5,598	6,795
Specific gravity	1·6–1·8	1·35–1·75	1·32–1·46

With regard to the extent of the area of the Udi-Okwoga coalfield within which outcrops of coal occur, the line of outcrops in the vicinity of the eastern escarpment extends northward from near the source of the Mamu river, south of Udi, to Otukpa, north-west of Okwoga, a distance of about 72 miles in a direct line. Coal is found outcropping almost continuously between these two localities. The westerly limit of the area runs northward from the Mamu river through the Oji river, via Oha Obenagu and Amandim in the Udi district, and thence within a few miles of Ogrugru to Angba in the Idah district. In the Udi district, the width of the area, in an east to west direction, over which outcrops have been observed, is about 10 miles. The area widens northward, until at the northerly limit, as at present known in the Okwoga and Idah districts, its width is about 40 miles. Assuming the area thus defined to have an average width from east to west of about 25 miles, the area over which known outcrops occur amounts to about 1,800 square miles.

A colliery, known as the Udi Colliery, has now been established in the vicinity of Enugu Ngwo, where an adit has been driven in the Obweti Valley. Work is proceeding by the bord-and-pillar system. The roof requires careful timbering. Local timber has been used, but this is becoming scarce, and supplies are now being obtained from Lagos. The timber loses its strength rapidly, partly through dry rot, and partly through the activity of the borer beetle. There is a fairly plentiful supply of labour. The local bush natives are good colliers, and are working on the piece system. In November 1915 between 600 and 700 men were employed at the mines. The output of coal up to December 31, 1915, was 7,182 tons.

Further details regarding the distribution of coal in the Udi-Okwoga coalfield, and analyses of samples, can be obtained from the official reports on the results of the Mineral Survey of Southern Nigeria, which have been published in the Miscellaneous Series of Colonial Reports. These are obtainable in London from the Government printers.

GEOLOGICAL MAPPING AS APPLIED TO OILFIELDS.

At the meeting of the Institution of Petroleum Technologists held on December 19, S. Lister James read a paper on Geological Mapping as applied to Oilfields. We quote some of the author's remarks.

As a primary instruction the author impresses on us the fact that prospecting for oil does not consist merely in the search for anticlines by the collection of dips. The fundamental point is not that oil necessarily collects only in domes and anticlines, but that it is lighter than water. The consequence of its lower specific gravity is that it is liable to be driven out gradually at the outcrop or to be retained under pressure on encountering a barrier. This barrier may take the form of an impervious arch in the overlying beds, a fault plane, a plane of unconformability or of overlap, etc., or the oil rock may be of lenticular form between two impermeable beds which merge up the dip.

To show an anticlinal axis merely on the evidence of opposing dips is an unjustifiable procedure ; quite different series showing opposing dips may in fact be brought in contact by faulting. Again, in the case of a highly inclined monocline, strata, especially those of soft nature, may be terminally curved so as to show an apparent reversal of dip. Where a consideration of the general evidence leaves no doubt as to the continuation of the monocline such dips are preferably not recorded, or if shown ought to be qualified by a query. Further, current bedding may give the impression of an anticline if opposing dips are considered necessarily to indicate the present of such. High angles are sometimes present in beds but slightly affected by tectonic movement, and even in thin shaly alternations of sand and clay, which one might expect to be free from current bedding. Where the structure is anticlinal, the pitch of the fold should, if possible, be determined with accuracy. Intermediate horizons may be mapped locally with advantage to portray local subordinate structure, or to show the correlation of different wells by their position with reference to an index horizon.

In oil geology the actual determination of the age of a series is not considered to be of primary importance, local classification being sufficient for practical purposes. Palæontology may do considerable service in supplementing mapping. Its value in correlating self-contained areas, isolated by newer unconformable deposits, will be obvious, if the series be zoned throughout at its outcrop. Elaborate mapping in the middle of a group, without any special object such as the correlation of different wells or the portrayal of local structure, is to be avoided. Mapping should rather be kept to the vicinity of group-boundaries to prove faults, unconformities, or overlaps. In the case of a highly complicated and obscure region, the first observer may, through lack of time or insufficient experience, fail to solve all its important problems. But the accurate and unbiased recording of evidence will at any rate greatly facilitate the ultimate correct interpretation of the full geological history, which should be the preliminary to selection of sites for test wells.

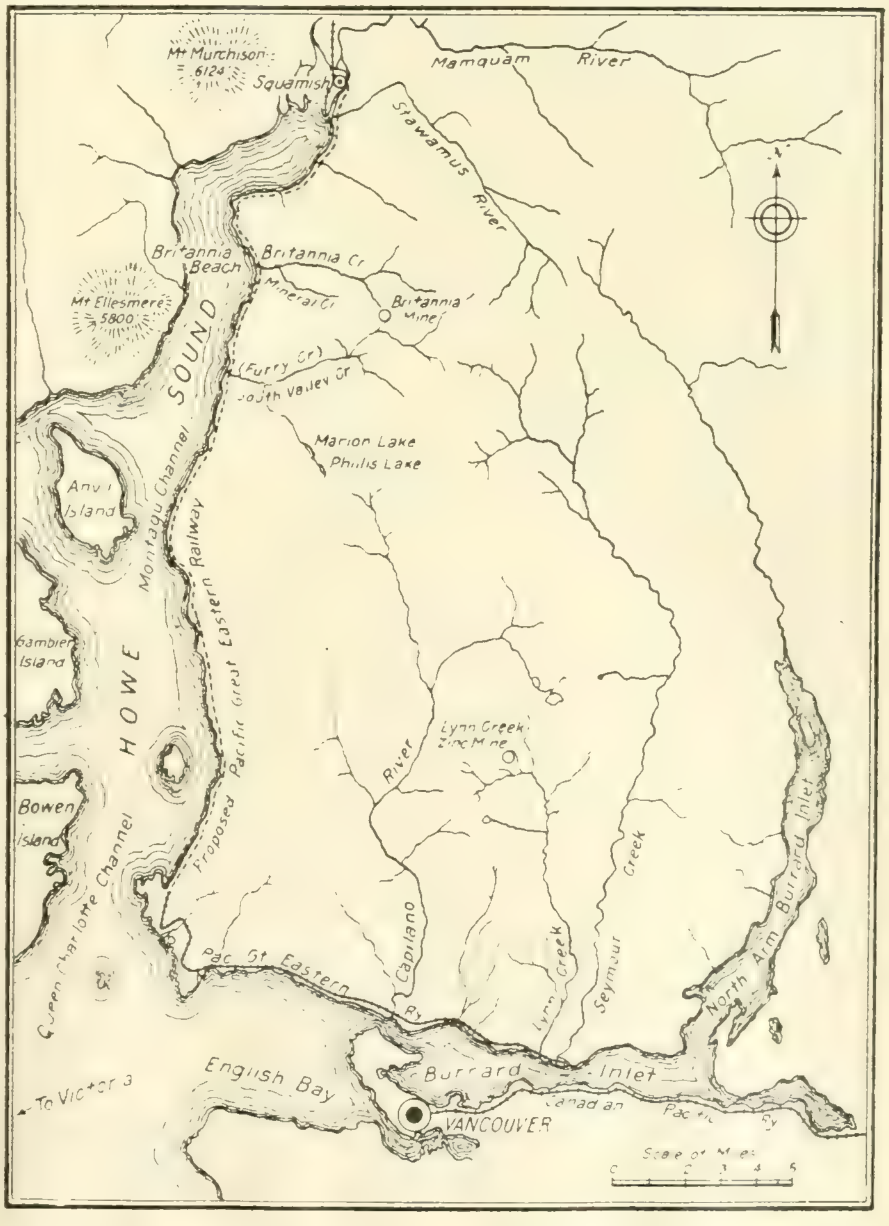
It is essential in a homogeneous alternating series, as most oil series are, at least in the author's experience, actually to trace with care the individual horizons. However laborious this may appear to be, it is a habit which should be cultivated. Only in this manner can faults be proved definitely and traced, and slight unconformities and overlaps be demonstrated. Furthermore it is by following individual beds that we learn the significance of lateral variation and develop the ability to read physical features, a matter of importance when actual exposures are lacking. It is in this way that we learn to recognize and discount the false evidence of current bedding, terminal curvature, contemporaneous erosion, etc.

The author proceeds to quote a particular case in its connection with detailed mapping, namely, an elongated dome. We first proceed to some suitable high point whence we can get an extensive general view of our area. We see, let us say, bed after bed of sandstone, alternating with clays, forming excellent scarps, and dip slopes. The structure is absolutely clear ; we can see these beds successively swinging over the crest at either end of the dome and joining up on the other flank. But how are we to embody in the form of a map the essentials of what we see before us ? To record a number of dips all over the area will be wholly inadequate ; while, on the other hand, to trace every sandstone band that we see is entirely unnecessary and out of the question as employing too much time. But let us select for mapping a few of the most prominent beds at vertical intervals of perhaps 200 to 300 ft., extending from near the crest to some distance down the flank, according to the steepness of dip. Now we should make a point of keeping to these horizons, and not to be constantly changing to fresh ones, as there is a strong tendency in the beginner to do. Where, however, one bed becomes obscured for a space, it is justifiable, in fact advisable, to trace a neighbouring horizon until the original one can be picked up again. Such a course will guard against the possibility of overlooking a fault. It is much easier to follow the course of a bed than to put it on paper. But the mapping of a bed merely consists in surveying two lines, the one at the base of the bed, the other at its junction with the overlying stratum. Where the bed occurs in a scarp face, these lines will obviously be close together; while with a dip-slope they will diverge, the upper one being drawn at the foot of the dip-slope. These remarks apply equally to a band a foot thick as to a thick group.

Another interesting section of the paper relates to the mapping of forest lands. We shall quote this on some future occasion when illustrations are available.

THE BRITANNIA COPPER MINE, BRITISH COLUMBIA.

Our good friend Mr. T. A. Rickard made a journey of observation last summer to British Columbia, and he is now publishing a series of articles in the *Mining and Scientific Press* recounting some of his experiences and putting on record the facts and views collected. In the issue of November 11 he describes the Britannia mine, which is situated behind Howe Sound and 30 miles from Vancouver. This is the biggest copper mine in the British Empire. Like so many of the big low-grade copper or gold deposits on the western side of the North and South American continents, this deposit was offered unsuccessfully in London. H. C. Walters was in London for this purpose in 1901, and J. D. Kendall was sent out to make an examination for a capitalist. Mr. Kendall wrote an excellent report, which has since been substantiated by results, but ore containing 2% copper was not attractive in those days, and the proposals were dropped. In its early days, from its discovery in 1888 until 1912, when Grant B. Schley, who came into personal control in 1908, put J. W. D. Moodie in charge, the deposit was the cause of many disappointments and misadventures. In 1912 the concentrator was remodelled, and its daily capacity increased from 500 to 850 tons. Subsequently an entirely new mill with a daily capacity of 2,500 tons has been built; at the time of Mr. Rickard's visit it was treating 1,700 tons daily. The development was pressed energetically, with the result that the deposit was proved to be very extensive. A rough estimate of the assured ore is 17,000,000 tons. The deposit is in mountainous country, and is opened by adits, from which rises are driven. The system of shrinkage stoping has been adopted, and the reserve of broken ore in the stopes is about 700,000 tons. The deposit is not a single vein or even a series of them, but a big width of schist enriched by seams of chalcopyrite. Eleven veins have so far been noted in a belt 800 ft. wide. The average stoping width of each vein is 30 ft. with a maximum of 80 ft. These widths are, however, only provisional estimates, and may be exceeded in many cases. The separate orebodies have been proved 1,000 ft. in length and 1,600 ft. in depth. The chalcopyrite is contained mainly in fissured channels in a silicified sericitic schist adjacent to a diorite porphyry. Near the ore the schist is spotted with chlorite. Zinc-blende is also present, and at one time the intention was to save it. An analysis of the mill feed during September was 2·74% copper, 7·95% iron, 1·5% zinc, 6% sulphur, and 71·25% silica, with a trace of gold and about ½oz. of silver per ton. The ore is of medium hardness, and



breaks readily, loosening the chalcopyrite. It is crushed in breakers, and after the removal on picking belts of some shipping ore, it goes to rolls where it is crushed to pass ¼ inch holes. It is then separated into coarse and fine products in a trommel with 1·5 millimetre holes. The coarse is sent to Hancock jigs, where a concentrate and tailing are obtained. The fine goes to Overstrom tables, The tailing from the jigs is further reduced in fine rolls from ¼ inch to 2 mm. and sent to tube-mills, where it is reduced to a size suitable for the Minerals Separation flotation plant. The tailing from the tables is separated in a de-watering tank into slime and sand, the latter going to the tube-mills, and the former after thickening going direct to the flotation plant. The scheme of the whole dressing plant is so arranged that a concentrate is produced having iron and silica contents such as will make the concentrate self-fluxing. The average recovery of the copper is 94%. The average content of the concentrate is 15% copper, 4·5 dwt. gold, and 1·65 oz. silver. This and the picked ore are shipped to the Tacoma smelter.

DECAY OF MINE TIMBERS.

At the December meeting of the Midland Institute of Mining, Civil, and Mechanical Engineers, J. Mitchell, of the botanical department of the Imperial College of Science and Technology, read a paper on some causes of the decay of mine timbers. He drew particular attention to the action of fungi as a direct factor in this decay. This experience shows that 50% of the wastage of timbers in the coal mines of this country is due to fungal attack. A more intimate knowledge of the fungi causing this decay, their method of attack, and mode of spread, is therefore necessary, in order to arrive at any reliable methods of checking this wastage. Anyone who has spent a few hours in a warm, damp mine will have been impressed by the luxuriance of certain fungal growths on the timbers, especially in small excavations on the side of roadways where the air is slack, and where there is usually a good deal of timber. It is a general experience that where these fungi are most prevalent, decay is rapid, and the timber has to be replaced very frequently.

These fungi commence their life history as microscopic spores, which are blown about or are carried by insects, etc. Under suitable conditions of warmth and moisture, they germinate on the surface or in the cracks of the timber, and produce threads which penetrate and feed on the substance of the wood. By the action of certain enzymes excreted by the fungus threads, the wood is rendered more fragile or brittle, so that it eventually breaks under pressures much lower than those which it can bear when healthy. This is known as the vegetative stage of growth, and the threads are known as mycelia. Then, certain growths, in the form of cushions, brackets, or incrustations, appear on the surface of the affected timber, and produce microscopic spores. This is known as the reproductive stage, and the various growths are known as fructifications. The ripe spores become detached, and the cycle re-commences.

The fungi found in mines can be roughly grouped under two types, based on the method of growth of the mycelium, and those who are responsible for the timbering in mines should be familiar with the characteristics of the two types. Between these two there are certain forms which are intermediate in character, inclining to one or the other according to local conditions, but a little experience will allow of these being placed correctly for practical purposes.

Type 1 comprises those fungi which are characterized by an excessive development of surface mycelium. This grows over the timber in widespreading sheets or in long strands or cords; and it is this type which attracts most attention in mines.

Type 2 includes those fungi which show little or no external mycelium. They commence their growth in the cracks of the timber, but instead of growing outward to form sheets or cords, the mycelium remains inside the wood. Eventually the fructification appears on the surface of the wood as a cushion or bracket, and until this happens there is little to indicate that the timber is affected. A little consideration will show how dangerous the members of this type may be, particularly when we consider the question of falls of roof, the fragile or brittle state of the timber not being realized in time.

It is probable that one or more of these forms will be found in every mine in this country, the one or other predominating in accordance with the relative temperature and moisture, and, to a less extent, with the nature of the timber in use.

Mr. Mitchell proceeded to consider the significance of each of the above-mentioned types in relation to the decay caused by them.

As regards type 1, from the nature of growth of this type, it will be seen that, given a starting point for growth, all the timber in the vicinity is liable to become involved. Thus, if the fungus is growing on an upright, it becomes a simple matter for it to spread on to the adjacent roof, and thence to the prop on the opposite side of the roadway. In fact, timber at some considerable distance may be reached and enveloped owing to the fact that the fungus creeps over the walls, the roof, and any intervening object. Again, if actively growing mycelium is transferred to unaffected timber, it can continue growth, penetrate the timber, and thus create a new centre and source of supply. In those cases where fresh timbers are put in contact with affected timber, the greatest possible encouragement to the growth of the fungus is given. Another means of spread is supplied by the not uncommon practice of leaving pieces of diseased timber on the sides of roads or in small excavations. In some cases, broken timber is left behind the brick walls, so that one frequently sees the mycelium coming through the mortar and cracks in the wall. In course of time this spreads on to the timber in the roadway.

The examples quoted show how the fungus spreads by ordinary growth from centres, and also how many centres are created by transference of the mycelium from place to place. In addition to this, we get direct infection and spread through the medium of microscopic spores developed in the fructifications. In all these fructifications the ripe spores, as they fall, are carried along by the ventilating current and also on the wings and legs of insects which frequently inhabit the substance of fructification. Moreover, there is no doubt that spores are carried on the clothing of the miners as they pass along the roads. Under laboratory conditions, Polyporus vaillantii produces the fructification within a fortnight of the first appearance of mycelium on the wood, so that sporulation by this fungus probably takes place on a large scale in the mine, and in whatever way the spores are carried, they are eventually deposited on timber in other parts of the mine. Ordinary sawn timber (being very rough) is especially liable to collect spores in this way, and may become thoroughly infected in six weeks from the time it was placed. The warmth and humidity of the mine is ideal for the germination of the spores, and new infections are doubtless continuously being made. The very tiny tufts of white threads which appear on the surface of the timber represent the earliest stages of growth after infection.

The members of type 2 produce little or no external mycelium, so that infection and spread in this way is practically negligible. In these forms, the fungus may usually be seen in the cracks of the wood, and where pieces of wood have been broken off. Active growth continues inside the wood, causing it to become soft or brittle. Eventually the timber breaks, and, to an unpractised eye, the breakage is frequently assumed to be an ordinary one, and not as a result of fungus attack. That there are no signs of mycelium is no proof that it is not present, for it often requires microscopic examination to determine its presence.

As regards those preventive measures which consist of processes for the impregnation of timbers with various antiseptics, this is a large subject in itself, and one which requires thoroughly investigating in order to find out if equally effective but cheaper methods can be adopted. At the present time, the universal attitude toward this question of preservation of timber in mines is to regard the timbers used as a variable factor, and the conditions in the mine as a more or less constant factor. This being so, all attention is directed to the timber used, with a view to improving its condition before placing it in the mine. Again, if a particular kind of timber appears to decay more rapidly than another, that timber is regarded as inferior, and there is a tendency to discard it or limit its use, and reasons for inferiority are looked for in the direction of improper seasoning, etc. The variability of the timber used is doubtless an important factor, and will have to be taken into consideration in any comprehensive scheme for dealing with this question.

There is, however, another aspect of the question, namely, the condition of the mine itself, to which attention should be drawn, with a view to finding if the problem cannot be partly solved in another direction. It is probable that a material prolongation of the life of the timbers in mines would result if vigorous sanitary measures were adopted in the mines, and that timbers now regarded as unsuitable in mines, owing to their tendency to decay rapidly, would, in course of time, prove satisfactory if mine conditions were radically improved. Where fungi are allowed to grow unchecked both in their vegetative and reproductive stages, it is not surprising that decay is rapid.

Steps to improve sanitary conditions should be taken gradually, and on a well-considered plan. Each road throughout a mine might be systematically inspected, and a rough estimate be made of the relative amounts of decay taking place as a result of the attacks of the two types of fungi described. It is desirable that more accurate records should be kept of the times of placing and removing timbers and of the cause of decay, for in this way only can a true conception of the condition of the mine be arrived at.

In dealing with type 1, a progressive campaign should be undertaken on systematic lines, each road throughout the mine being carefully and thoroughly worked. In pointing out the various ways in which the fungi of this type spread through a mine, it was stated that, if left unchecked, the mycelium will spread from one place to another, and this suggests the desirability of removing the mycelium as soon as possible from any timber on which it is growing. This can be done by means of a cloth kept well soaked in 10% solution of copper sulphate. Where the mycelium adheres firmly to the timber, it might be removed by scraping with a knife, and the timber be subsequently washed with the copper sulphate solution. Where the timber is thoroughly permeated with the fungus, the surface growth of mycelium will doubtless re-appear from time to time, but there will be a retardation of growth, and a further application of copper sulphate solution in the manner advised will confine the growth to the timber infected at the time operations commenced. Wherever practicable, it would be advisable not to place sound timber in contact with infected timber. There are certain practical difficulties in carrying out this recommendation, but these might be overcome in time. Further, all waste timber should be taken out of the mine, and not left to lie about. Any diseased material removed during the course of these operations should be brought out of the mine and destroyed.

The fungi of type 2 are not so difficult to deal with. In this case the mine might be treated road by road, from the intake toward the return ways. Every sign of fructification or other similar growth should be removed, collected, brought to the surface, and destroyed. It must be remembered that, at the beginning of operations, each road is more or less infected with fungi of this kind, and many of the timbers may already be in a fairly advanced state of decay. In these circumstances, these fungal growths are likely to reappear from time to time until the timber now affected has been removed. The length of time it would take to clear a mine completely of these growths will largely depend on the existing degree of infection and the vigour with which the measures are maintained. There will, however, be a progressive decrease in spore production.

Mr. Mitchell's paper is well worth full study.

GEOLOGY OF THE INSIZWA RANGE.

The Insizwa range lies between the Drakensberg and the sea, and separates Griqualand East and Pondoland, the two easternmost sections of the Cape Province, South Africa. Copper deposits were discovered here in 1865, and the presence of nickel with the ores was recognized in the early nineties. Gold, silver, and platinum have increased the commercial and scientific interest in these deposits. The Government of South Africa commissioned A. L. Du Toit to make a geological survey, and his report was published in 1911. Two years ago, W. H. Goodchild paid a visit, and examined the district. His results have been given in a lengthy paper presented to the Institution of Mining and Metallurgy at the December meeting.

The base of the range is composed of horizontal sedimentary rock provisionally correlated with the middle or lower Beaufort beds of the Karroo system (Permo-Carboniferous), These rocks consist of thin bedded bluish sandstones, sandy mudstones, and shales, frequently containing small amounts of carbonate of lime. The same rocks are found at the plateau-like top of the range. Between the bottom and top series there is a sheet of intrusive gabbro averaging 2000 to 3000 ft. in thickness. The shape of this igneous mass is roughly that of a basin with a peripheral dip averaging 30°. The sedimentary rocks above and below have been subjected to metamorphism from contact with the intrusive, and have been changed to hornfels. The hornfels near the contact is a hard dark compact rock, microcrystalline in structure, and breaking with a conchoidal fracture. The gabbro and hornfels are more resistant to weathering than the sedimentaries, and therefore their outcrops stand out as steep escarpments.

In the lower horizon of the gabbro is found a zone of picrite, constituting the most basic or magnesian phase of the gabbro. This picrite contains disseminated sulphides of copper, nickel, and iron, which have been the object of some prospecting. Mr. Goodchild considers these deposits as affording good economic possibilities. In addition to this occurrence of ore, solid sulphide veins, of small dimensions and of irregular characteristics, are found near the hornfels-gabbro contact, extending short distances into both rocks. It is in these veins that the platinum, gold, and silver have been found. Much prospecting and development has been done on them, but the results have been disappointing owing to their limited extent and irregular nature. A third type of ore deposit is found in sheets of acid rock resembling steeply inclined dykes The sulphides occur in bunches and are also finely disseminated, and platinum is present. The dyke rock shows all variations from hornfels to microgranite. A fourth type consist of dolerite dykes cutting both the hornfels and gabbro. Their metal content is small, and their importance is due to the occurrence of niccolite in one of them. Mr. Goodchild discusses in great detail the origin of the igneous rocks, their differentiation by specific gravity, and the origin and formation of the metalliferous deposits, making comparisons with the occurrences in Namaqualand and Sudbury.

TIN DREDGING IN THE FEDERATED MALAY STATES.

The subject of bucket-dredging for tin in the Federated Malay States is greatly interesting the public and engineers at the present time, and the articles on this subject in this Magazine written by Harry D. Griffiths have attracted attention. It so happens that A. C. Perkins, the manager of the Malayan Tin Dredging Co., and associated with F. W. Payne in the design and working of dredges, read a paper on the subject before the Federated Malay States Chamber of Mines on November 11. We regret we have not space to publish his paper in full, but we give liberal extracts from it. It is possible that we risk some repetition in publishing this precis in addition to Mr. Griffiths' articles, but the subject is important, and the views of two competent authorities are worth having.

As regards the nature of the ground now being dredged, the Malayan Tin Co. is working low-lying river flats, very wet and swampy, and with much heavy timber buried at 20 to 30 ft. below surface. The ground is from 20 to 60 ft. or more deep, and consists for the greater part of sand, free karang, and heavy clay found in layers and clumps at varying depths, with a bedrock of pinnacle limestone. The tin is distributed more or less from top to bottom, but with the better values lying between 30 and 50 ft. deep. There is no regular bed of karang, but patches here and there at greatly varying depths. The Ipoh Tin Dredging Co.'s ground consists of old mining lands, the general characteristics of which are similar to those of the Malayan Tin Co. The large Tronoh dredge is working ground the surface of which stands 4 to 8 ft. above water-level, with the bedrock of limestone 61 ft. below water-level. The deposit is fairly sandy, but with considerable clay in places. A stratum of particularly hard cemented material occurs, which is very hard to dig. The tin is distributed throughout. The Chenderiang is working an open valley deposit of a fairly free character, but with some clay and large granite boulders. The ground is comparatively shallow and the bedrock is limestone. The above are all in the Kinta district.

On the Taiping flat the conditions are nearer ideal than elsewhere. The Kamunting dredge is working in a nice clean flat and digging free gravel and sand 30 to 45 ft. deep on a soft bedrock. Their worst digging trouble occurs when they strike an old boiler buried in what was once a Chinese lombong. The ground carries tin from top to bottom, and they are fortunate in having a good clean water supply from the hills. Kampong Kamunting has similar conditions, but with clay overburden on parts of the property. Further out on the flat Tekka Taiping has nice open dredging ground around 45 ft. deep with soft bedrock. The land is very flat with water near the surface. The deposits carry a large proportion of sand and fine gravel but with considerable clay overburden. Only a trace of tin is in the overburden. Down at Trong they have gone into the virgin jungle 25 miles from the railway, cleared the valley of timber and are working a narrow river flat with rapidly rising hills on either side. The surface conditions are good, the ground carrying clay overburden, with free sandy gravel and sands below lying on a soft bedrock.

As may be seen from the foregoing remarks, the Kinta field presents less favourable conditions for dredging as a general rule than Taiping. So far as present operations go, the principal difficulties are due to the presence of large quantities of clay, buried timber, and the limestone bedrock.

A dredge has of course its limitations, and the character of the ground has a direct bearing on the quantity of material that can either be dug or treated. With free gravel on a soft bedrock and good surface conditions it can do its maximum. There is, however, very little of this class of ground in the Federated Malay States. The presence of clay reduces both the digging and treating capacity of the dredge, and this is one of the principal problems to be dealt with in this field. The presence of buried timber in the ground adds to the difficulty of digging, and an excess of timber would make dredging impossible. An example of this class of ground may be seen on certain parts of the Taiping flat, where there is a buried mass of fallen trees and vegetable matter 10 to 15 ft. thick, which could not be successfully handled by dredging. It is nevertheless possible to handle very heavy timber in considerable quantities. On one occasion at the Malayan Tin property, great tree trunks some of them up to 90 ft. long and 3 to 4 ft. thick were raised by one of the dredges in considerable numbers This experience was sufficient to demonstrate that a few buried logs do not by any means block dredging operations.

The nature of the bedrock is a important feature in a dredging proposition. Soft decomposed rock is the ideal to work on, but in Kinta the limestone bottom is anything but soft. It is a feature of much mining land in Kinta that the tin is to some extent distributed throughout the mass of the deposit, with the bulk concentrated in the karang beds; and the difference between a possible and impossible proposition for dredging is largely determined on whether the tin lies close to the bedrock or not. In Kinta the nature of the limestone bedrock is such as to make a thorough clean-up of the bottom impossible with dredge buckets, and the best that can be done is to clean out the depressions and ruts in the rock as far as the sweep of the dredge buckets will allow. Apart from cleaning up the bottom, the actual bedrock itself is no serious obstacle to dredging operations.

The system of working adopted on the Malayan Tin Co.'s ground is that of cutting from the surface down and slicing the stuff off in thin horizontal layers across the cut until the highest part of the rock is reached. Below this, the ruts and depressions are cleaned out one by one until the whole of the bedrock has been scraped from side to side right across the cut. This method of cutting the ground has been found from experience to be the best under the conditions on the property in question. Of course the crevices and small ruts are not cleaned out, and an appreciable quantity of stuff must remain untouched. Where the chief values are found near the bedrock, extra care has to be taken and more time spent on the work, which means a reduction in yardage. On the Malayan Tin property, however, the values are by no means concentrated on the bedrock, and while there is some tin left behind, it is very doubtful whether the property could be made to pay by any system of working that would ensure a thorough clean-up of the bedrock.

The effect on machinery of contact between the moving buckets and the hard bedrock is not serious, as suitable provision is made for automatic release. In the event of a bucket taking a hard bite of the rock, the clutch slips and prevents breakdown. If, however, the machine were not of ample strength the dredge would very soon be pulled to pieces.

Mr. Perkins proceeds to give details of the design and performance of twelve dredges at work, four belonging to the Malayan Co., and one each to the Tronoh, Ipoh, Kamunting, Chenderiang, Tekka Taiping, Kampong Kamunting, Trong, and Larut. Of these all have open-connected buckets except the last three, which by the way, are of Australian design. There is some difference of opinion as to the relative advantages of open and close-connected buckets, and as a digging machine probably the close-connected bucket has advantages. In a well designed bucket it has important advantages in possessing much larger wearing surfaces both on pins and bushes and treads on tumblers. When, however, there are large boulders or logs to contend with, the open-connected type has the advantage in being better adapted for dealing with such obstructions, and it becomes a question which outweighs the other.

The variation in the yardage treated according to the nature of the ground is well exemplified by the performances of the Ipoh Tin and Kamunting dredges. These are practically duplicate one of the other, each with 10 cu. ft. buckets, the former running 15 per minute and the latter 12 per minute. Ipoh Tin is dredging stiff clayey ground on a hard rough limestone bedrock, and digs 108 yd. per hour at a digging efficiency of 32·4%. Kamunting is dredging free sandy gravel on a soft decomposed bedrock and digs 161 yd. per hour with 60% digging efficiency. A further comparison may be made between Malayan Nos. 2 and 3, two dredges that are of equal capacity and power. The former while working very difficult clay ground on a very rough hard bedrock has dug 120·8 yd. per hour with 45% digging efficiency. No. 3 on somewhat less clayey ground and a more even hard bedrock has dug 152·6 yd. per hour with 57% digging efficiency. In this case the difference is largely caused by extra time taken in cleaning up the bedrock by No. 2.

Speaking generally in regard to the question of digging it is important that the dredge should dig as much as possible, but this must be governed by the quantity of material the tin-saving end of the dredge is able to take care of. While it is fully recognized that the digging end of the dredge is important, and considerable improvements are possible to meet local conditions, it nevertheless is not by any means the most important in dealing with the question of tin-dredging in Malaya. The dredge as a digging machine is much farther advanced than as a tin-saving machine, and it is useless to dig more stuff than the screen and boxes can treat.

The problem of breaking up and washing the materials presents one of the chief difficulties. The difficulty is partly due to the large amount of material to be handled and the limited space available for doing the work, but chiefly to the nature of the materials. The dredges have digging capacities ranging from 240 to 350 cu. yd. per hour or 4 to nearly 6 cu. yd. per minute, and much of the ground worked is of a very clayey character. Anyone familiar with breaking up clayey karang can form some idea of the work entailed in dealing with clayey materials at such a rate.

The appliances in general use for this purpose consist of the revolving perforated screen, provided with a sparge pipe, and various contrivances for breaking up and roughly sizing the material and passing on the sands and tin to the streaming boxes. Several patterns of screens are in use: that on the Bluck design of dredges as at Kamunting is the plain perforated revolving cylinder, through which the material quietly passes while being sprayed with water under a very low pressure. This screen exercises the function of screening only, and what washing is done is due simply to the water falling on top of the material. This type of equipment was commonly used on gold dredges in New Zealand many years ago, and it is suitable only for washing free gravel where there is no clayey matter. The Australian type of dredge, as at Kampong Kamunting, is fitted with the step screen in which the material is subject to a series of drops during each revolution of the screen, and this gives it a turn over and exposes all sides of the material to the spray from the screen pipe. This screen does much better work than the old plain pattern, and a point in its favour is the facility with which the plates when worn can be replaced. It is not, however, equal to the task of breaking up clayey karang. The Malayan Tin dredges and Tronoh large dredge are equipped with screens of the cylindrical type, fitted with retarding angles, and armed with series of cutters, which tear and chop the stuff about during its passage through the screen, while at the same time it is exposed to the washing and cutting action of numerous strong jets of water under considerable pressure from the screen pipe. This outfit is found to give fairly satisfactory results in dealing with the class of tin-bearing material usually found on the Malayan Tin company's ground. It nevertheless still leaves something to be desired.

That there is considerable loss of tin from dredges due to imperfect washing is scarcely open to question. The best appliances at present in use are not equal to the task of completely breaking up bad clay.

The appliance in general use for saving the tin consists of a series of sluice-boxes of the common type fitted with stops at varying intervals. The individual box is usually about 4 ft. wide and from 80 to 100 ft. long, and placed at an inclination of 1 in 24. The material and water are under control and are distributed to the various boxes as required. The boxes are tended by Chinese coolies, whose business it is to preserve an even steady flow throughout the entire length of the box, and to keep alive the accumulating beds of sand in which the tin settles. A clean-up is usually made once in 24 hours, but in some cases oftener. The general practice in the Kinta district is to clean up while the buckets continue digging, but in Taiping district dredging is suspended while cleaning up. The merits of any particular plan depend upon the facilities for doing the work. Where there is ample table area the clean-up can be made while running without danger of serious loss of tin and with a gain of about two hours dredging time per day.

The distribution of the sands and regulation of the water are important, and one man, usually the shift kapala, attends to this. It is his duty to adjust the flow so as to evenly distribute to the sets of boxes on each side and give each box its fair proportion of sand. In the event of a heavier feed being passed for a little time to one side than the other, the dredge will list and this immediately throws all the boxes out of trim. Under working conditions the feed from the buckets through the screen is irregular and depends upon the character of the stuff being dredged. Sudden changes occur in the ground such as from sand to pug clay. Practically the whole of the sand would pass on to the tables, and possibly not more than 10% of the clay. Such a change calls for immediate regulation of the water.

The slope at which the boxes are fixed on the dredge is 1 in 24, and this may be taken as the standard of present practice. It is of course subject to any irregularity in the fore and aft trim of the dredge pontoon. The question of preserving the grade presents some difficulty. It has to be remembered that the working load on the boxes varies considerably, and that the difference in weight between empty and full is in the region of 100 to 150 tons on single-bank boxes and 200 tons or upwards on double-bank boxes. Water ballast tanks are sometimes employed to regulate the trim. These, however, unless under constant and reliable European supervision, are unsatisfactory and a source of danger, and in any case they are not necessary. The secret of a well balanced dredge under running conditions rests in the proportions and design of the hull and arrangement of boxes thereon.

A common cause of irregular trim is overloading of the boxes. A given quantity of water will only carry a certain amount of sand on a given grade, and when more sand is piled in, the box will block, or if free to go down, will continue to do so until the grade is sufficient to carry the extra material with the same quantity of water. This is what sometimes happens, and some of the dredges may be seen lying at least 2 ft. lower at the stern than at the bow. This means that the boxes instead of having a grade of 1 in 24 as intended are running with a grade of 1 in 18, or one-third greater fall. Under such conditions it is difficult to see how it is possible to avoid losing tin.

In a well designed plant the boxes are not seriously affected either by the action of the buckets or by the elevation of the main ladder.

Mr. Perkins then gives in tabular form particulars of the boxes on the various dredges. It has been proved from experience that width of flow is of much greater importance than length of run in tin-saving boxes. In order to increase the width the double-bank arrangement of boxes has been introduced. They may be seen in operation on the Malayan Tin and Tronoh dredges. Their introduction has greatly reduced the rate of flow in the boxes, and it is now around 2 yd. per hour per ft. of width, as compared with 4 to 5 yd. per hour in dredges of the single-bank arrangement. With boxes of this description there is little danger of serious loss under proper care. The weak point is the human element. Dependence has to be placed on the Chinese kapala and coolies for keeping the boxes in a fit condition, and neglect or carelessness must result in the loss of tin. Efforts have been made to replace the men in the boxes by the introduction of mechanical rakes, but without much success.

DIAPHRAGM PUMPS FOR SLIME.

The December issue of the *Bulletin* of the Canadian Mining Institute contains a paper by L. B. Eames discussing the Dorr counter-current system of decantation as applied to cyaniding slime, with particular reference to practice at the Hollinger gold mine, Porcupine, Ontario. Mr. Eames assisted Mr. Dorr in the design of the first Dorr plant, erected in 1910 at the Vulture mines, Wickenburg, Arizona. The paper is too lengthy to quote here, but we extract some useful remarks relating to the performance of diaphragm pumps employed in transferring thickened slime from one vat to the next.

As a means of transferring pulp the diaphragm pump is preferred to all others for the reason that it not only pumps efficiently but at the same time measures the volume of pulp transferred; also the flow of pulp is not easily obstructed by foreign matter, such as chips, waste and the like, as there is no contraction of the full bore of the pipe throughout its entire length. The capacity of the pump can be controlled with certainty by means of cone pulleys. As it is operated from the overflow level instead of at the bottom of the vat the attendant's duties are confined to one floor. The operating cost of a properly designed pump is very low. Air lifts were used for a time because of their cheapness and simplicity, but they are both wasteful of power and are hard to regulate; the most careful watching will not prevent them from running away, that is, transferring too fast and consequently thinning the pulp and therefore sending large quantities of rich underflow solution toward the discharge. If, on the other hand, they are set too slow the gradual thickening of the discharge diminishes the flow and finally stops it. Spigot discharge to a bucket elevator or centrifugal pump sump has also been tried, the pulp and solution being mixed and elevated together. There are, however, several objections to this arrangement, the principal one being the increased cost for more power and for maintenance of pumping or elevating machinery. Both solution and pulp must be elevated more than the full height of the vat for each decantation. The small stream of pulp passing through a spigot at relatively high velocity and pressure is subject to frequent stoppages from foreign matter, and even when this does not completely block the spigot it interferes with uniformity in operation; in addition two floors have to be served, one below and one above, or near, the top of the vats.

Some prejudice has been engendered against diaphragm pumps because some of the earlier makes were poorly designed for the work required of them. In addition, defective valves and poor regulation were responsible for much inefficiency. In present practice in most plants in the Porcupine district, cone pulleys are used !or the regulation of capacity, although some operators favour regulation by varying length of stroke. The valves should be of the floating type, as any hinge device will catch the wood chips that are present in the best screened pulp. The chips lodging in the hinge of the valve cause leaks, which, though small at first, cause cutting of the seat and consequent permanent leakage. With the floating valve there is no place for chips to lodge, and the whole circumference of the seat is washed by the pulp at every stroke. This type of valve also has the advantage that the lower valve may be placed directly below the upper one and may be made small enough to be lifted out through the upper valve-seat after the upper valve has been removed. As no tools are required for the removal of these valves it is a simple matter to inspect them. The best results have been obtained when the working surfaces of both the valve and seat were of high-grade rubber. At first belting was used, but it was found that minute leaks were sure to start, because belting is not yielding enough to close over any chip that may lodge on the valve-seat; a leak thus started ruins both valve and seat in the course of a few days. On the other hand valves of rubber, seating on rubber, have been in use six months without the slightest decrease in efficiency and scarcely perceptible wear.

Diaphragm pumps have been operated at speeds varying from 15 to 100, the higher speeds usually in conjunction with a short stroke. The practice at the Hollinger mill has been to use low speed and a stroke as long as the diaphragm can safely stand. Measurements taken on the Hollinger pumps gave results which showed that the volume pumped is roughly proportional to the speed of the pump, but that leakage is slightly greater on the lower speeds.

By low speeds and by placing the discharge lips high enough above the discharge valve to allow 3 or 4 in. of pulp over the valve at the end of the up stroke, the diaphragm pumps of the Porcupine district are practically free of the splash and dirt that heretofore have been two of the chief objections to them. Where vats have a settling capacity of over 125 tons of solids per day it may be found advisable to use two diaphragm pumps in parallel, making a duplex, or even a triplex, pump. This arrangement has its several advantages; at the lower speed strains of the pump are lessened and distributed; repairs can also be made on one unit without complete stoppage of the vat discharge. To guard against troubles caused by foreign matter, it is advisable to screen the pulp before it goes to the decantation vats: and where small wood chips are to be expected a fairly fine screen, usually of punched plate, will be of great service in protecting thickeners and pumps.

RECENT PATENTS

12,799 of 1915. METALS RECOVERY CO., LTD., and R. W. E. MACIVOR, London. Extraction of Zinc. This process is applicable to lead-zinc sulphide ores containing iron. The ore is crushed to 100-mesh or finer, and is separated into sand and slime, the pyrite going mostly into the former. The sand is given a sulphating roast. With the furnace charge is mixed a certain proportion of a previous charge containing ferric oxide. The function of the ferric oxide is to act as a catalytic agent to change a large part of the sulphurous fume given off in roasting into sulphuric acid, which serves to form zinc sulphate from such zinc oxide as is produced by roasting the sulphide. The roasted ore is then leached in sulphuric acid solution. Ferrous and ferric sulphates are dissolved also, To remove these, the solution is sent to another vat containing a fresh roast, where the oxide of zinc reacts on them and changes them into ferric and ferrous hydrates. Some of the liquor containing the iron sulphate is employed for treating the slime, zinc sulphate being produced,

13,856 of 1915. E. E. DE ST. LAURENT and ALUMINIUM SOLDER CO., London. Aluminium Solder.

14,662 of 1915. G. TOFANI, Rome. Cyanamide. The inventor describes improvements in the process for producing calcium cyanamide by reacting on calcium carbide with impure nitrogen or with air.

15,084 of 1915. M. J. TRUMBLE, Los Angeles, California. Converting Heavy Petroleum into Light Oils.

15,163 of 1915. T. TWYNAM, Redcar, Yorkshire. Refractory Bricks.

15,759 of 1915. F. G. WHEELER, Appleton, Wisconsin. Cathode for Electrolytic Cells.

16,643 of 1915. H. C. JENKINS, London. Electrolytic cells for the production of nitric acid from nitrates.

16,636 of 1915. U. C. TAINTON, London, and J. N. PRING, Sandbach. Electro-Deposition of Zinc. In their patent 7,235 of 1911, the inventors described the electrolytic deposition of zinc from a saturated solution of zinc sulphate, to which is added extra sulphuric acid and a colloidal substance, and employing a current of high density. According to the present invention no colloid is used. The proportion of added sulphuric acid is 16%, and a current density of 600 amperes per square foot is used.

16,658 of 1915. W. B. BOTTOMLEY, London. Improvements in the inventor's patent 17,487 of 1912, which described a method of producing ammonia compounds useful as fertilizers by bacterial treatment of peat.

192 of 1916. E. HAYNES, Kokomo, Indiana. Cobalt-Chromium Alloys.

1,278 of 1916. MACKAY COPPER PROCESS CO., Norwich, Connecticut. Structure of Electrolytic Cells.

2,424 of 1916. J. G. SQUIRE, Newcastle-on-Tyne. Roasting Furnace for Copper Ore and Matte.

2,584 of 1916. W. J. WRIGHTON, Philadelphia. Electric Furnace.

3,084, 3,099, 3,127, and 11,185 of 1916. DEUTSCHE GOLD UND SILBER SCHEIDE ANSTALT, Frankfort-on-Main. Electrolytic Production of Sodium Perborate.

7,119 of 1916. A. RAMEN, Helsingborg, Sweden. For precipitating copper from solution by means of scrap, employing a rotating vessel from which the solution containing precipitate mud goes to a filter-press for the recovery of the latter.

Slater's Copper-Leaching Process.—In our issue of March 1914 we described the process for leaching copper ores invented by H. B. Slater. The United States patents are 1,195,616 and 1,195,617.

NEW BOOKS AND OTHER PUBLICATIONS

The Elements of Mining. By George J. Young. Cloth, octavo, 628 pages, with many illustrations; price 21s. net. New York: McGraw-Hill Book Co.; London: Hill Publishing Co., Ld.

In this work no distinction is made between metalliferous, non-metalliferous, and stone mining; all are drawn upon for illustration. In the introduction, ore occurrence, ore values, and ore prices are treated, and the reader at once, and rightly so, makes acquaintance with the business aspect of mining. In so practical an introduction, the classification of deposits according to their probable genesis appears a little out of place; a classification according to the mode of occurrence would have been more apt.

Following this, the actual operations of mining are described in the sequence: prospecting, boring, drilling, breaking, transportation, hoisting, drainage, ventilation, and support; and then the application of these operations in open-pit mining, alluvial mining, and underground mining, upon which subjects there are separate chapters, underground mining having two chapters, upon development and stoping methods respectively. It would appear to the reviewer that here would have been the place to treat coal mining and stone mining in separate description. In sequence then come: organization, accounts, and accidents; and finally a chapter touching upon mine valuation.

The fact that the publishers contemplate a separate book to include transportation and hoisting is the reason that these two important subjects receive inadequate attention and no illustrations. Other than this the elements of mining are admirably set forth, the treatment of breaking, support, and stoping methods being particularly well and fully described.

One or two things are missed. For instance, in prospecting, no mention is made of the characteristic outcrops of deposits; in alluvial mining, no mention is made of suction dredging. It is also the case that the mining described is American mining, and reference to practice elsewhere is exceptional.

The author is to be congratulated upon his work. The book is one that contains a mass of interesting and valuable information in very readable form; it is essentially modern in text, illustration, and treatment, and can be highly recommended both to students in training and engineers in practice.

S.J.T.

The Flotation Process. By Herbert A. Megraw. Cloth, octavo, 250 pages, illustrated. Price 12s. 6d. net. New York: McGraw-Hill Book Co.; London: Hill Publishing Co., Ld.

This book is a compilation from various sources, chiefly "Concentrating Ores by Flotation," by Mr. T. J. Hoover, the *Mining and Scientific Press*, *Metallurgical and Chemical Engineering*, *Engineering and Mining Journal*, and various papers read before the Mining Institutes. It is the third book now published on the subject, the others being Mr. Hoover's book already mentioned and "The Flotation Process" by Mr. T. A. Rickard. It is unfortunate that the author should have taken a title exactly similar to that used by Mr. Rickard, for confusion must necessarily follow. There have not been so many books published on the subject but that a little ingenuity could easily have found another title, equally descriptive, without infringing on that already given to a similar work.

The book, however, in other directions shows signs of hasty compilation, as for example the chapter on Patents. It is true the author attempts to excuse himself by saying "I have made no attempt to catalogue all patents that have to do with flotation, and only those which seem to be of practical importance to subsequent commercial work have been mentioned." Then, having devoted nine pages to the patent and personal history of Mrs. Carrie Everson—a patent that long ago would have been left peacefully slumbering in the dusty archives of the Patent Office but that it has served as a bonanza in adding to the incomes of the patent agents and attorneys—he altogether omits to mention the patents of Sulman, Picard, Ballot, and Hoover, upon which the Minerals Separation process is based. As over one-third of the book bears directly on the Minerals Separation process and installations, it seems, to say the least, a little ungrateful especially to those who know the part that the firm of Sulman & Picard had played in the development and success of the flotation process, when it was introduced to the United States as a proved and practical system for the treatment of ores hitherto regarded as untreatable or only partially recoverable. The method of heading paragraphs such as "Robson & Crowder" (p.13) and then including under the same heading Frank Elmore's bulk-oil process patent calls for criticism. In fact the subject of Patents was so far more fully and efficiently dealt with in Hoover's book that it might to advantage have been omitted by Mr. Megraw.

In the description of the Murex process (p.91) it states "The magnetic paint is made up of oil-gas tar mixed with twice its weight of finely ground *cast iron*"; elsewhere magnetite is mentioned, and seems more suitable. On page 93 is a misprint in the sentence "A hundred pound lot of ore . . . . . suspended in 80 lb. of water. To this was added 4 lb. of finely ground magnetite in two *tons* of Texas residuum oil." This of course should read 2 lb.

The reference to the De Bavay process, "This process was installed in one or two places in Australia, and is said to have been a success" hardly describes the facts fairly, for figures as to tonnages and profits have been published by the company owning the De Bavay patents and leave no doubt as to the success of the process on ores for which it was evolved. These data were available to the author. These and other errors and omissions help to lessen the value of the volume as a reference work.

The chapter on the "Theory of Flotation" is interesting, as roughly summarizing the theories put forth to account for the effects produced by the various flotation processes. Most of the theories assume the coating of the sulphide particles with the oils. In many cases this "coating" is doubtful so far as frothing or buoying agents are concerned, and one is forced to the conclusion that, just as the tendency is to simplify the apparatus in connection with flotation, so also explanations of the cause of the phenomena will also prove more simple than they are at present made to appear.

The chapter on "Oils and their Uses" should prove useful to engineers experimenting with the process. Hardly enough emphasis has been laid, in any of the books published, on the fact that apart from the condition of the ore in relation to the suitable oil, the results are very much influenced by the condition of the working solutions and even of the apparatus itself. In one case the resin in the wood used caused considerable trouble. Experiments should when possible be carried out in the water it is intended to use in practice.

The chapter No. 6 deals with "Testing Ores for Flotation," and has its reason in the introduction of the Callow and other later forms of apparatus developed since Hoover's first edition of 1912. Chapters 7 to 12 are devoted to descriptions of various experiments and to the plants now using flotation. They deal exhaustively with the work at Anaconda, and the thanks of the mining and metallurgical world are due to the management and engineers for the way they have placed the results of their experiments and work at the disposal of their confreres.

The importance and utility of these processes are daily becoming more evident, and the development of differential or selective flotation opens a wide field for experiment. The treatment of slime has been revolutionized, and what formerly was a bugbear to the mill superintendent is now in many cases one of his chief assets.

Any book which helps to throw light on the subject of flotation and keeps the engineer abreast of the work being done must be welcome, and one only regrets that this book should so closely follow that of Mr. Rickard, and thus largely cover the same ground.

Alfred K. Burn.

The American Petroleum Industry. By R. F. Bacon and W. A. Hamor. Two volumes,970 pages, illustrated. Price 42s. net. New York: McGraw-Hill Book Co.; London: Hill Publishing Co.

This work, in two volumes, forms a valuable addition to the literature on petroleum, and is of particular interest to the refinery man. The title is too comprehensive, in that the subject matter chiefly deals with the physics, chemistry, and refining of liquid petroleum in the United States, the geology and oilfield technology being entirely subordinate. Judging from their introductory remarks the authors appear to have realized this. Seeing, however, that reference has been made to various phases of the American petroleum industry, it is to be regretted that the subject of oil-land law has among others been omitted, as well as the consideration of the important branches relating to the gaseous and solid bitumens, without a proper discussion of which no work on the industry as a whole is complete.

The treatise begins in Chapter I. with a short but well-considered summary dealing with the published work on the composition and genesis of petroleum. In Chapter IV. an excellent résumé of the physical and chemical properties of petroleum is given, but we are inclined to think that the tests adopted by the International Petroleum Commission given in Chapter XII. might have been embodied in it, instead of splitting up the chemical and physical examination into two sections. The tables for the conversion of Saybolt and Engler viscosities might well have been amplified by the addition of factors for the Redwood viscometer which is the standard in the British Empire. The tables of physical properties are comprehensive and supply a long felt want, containing as they do accurate information as to the source of the oils. The quality of these chapters is high and the references comprehensive.

The chief feature in the too short chapter by F. G. Clapp on the geology of petroleum is the elaboration of his well known classification of petroleum occurrences, based on geologic structure. Oil well technology is treated briefly but capably in Chapter VI., in which is summarized the present practice in the United States. While, however, a full account is given of the modern methods of cementing wells, the "mudding-up" process now used with such excellent results on the mid-continental and other oil and gas districts is not described. Within the space allotted it is obviously impossible to do more than cursorily introduce this most important branch of the petroleum industry.

Of particular importance and value to the student are the thoughtful contributions, accompanied by illustrative graphs, of Professor Roswell H. Johnson on the valuation of oil properties, and on the efficiency in the production of petroleum, and those by L. G. Huntley on possible causes of the decline of oil-wells and suggested methods of prolonging yield. Professor Johnson's protest, in the interest of conservation and of sound practice, against the fixed royalties ($\frac{1}{8}$ to $\frac{1}{6}$), and the tendency to restrict the size of area, prevailing in the United States, would appear exaggerated when the excessive royalties and small area under which producing companies labour on European and Russian fields are considered, were his remonstrance and his demand for a sliding scale in respect of royalties and for adequate areas not fully justified. The necessity for natural gas being under the same control as oil is also clearly set forth.

The compressed-air and water-flush methods—still in the experimental stage—of expulsion of oil and of its recovery from almost exhausted sands are also discussed. The discussions on the leasing of oil lands, on methods of locating and spacing of bore-holes, and on management and cleaning of wells are suggestive and welcome. The chapter on natural-gas and gasoline, otherwise excellent, is inadequate in that it makes no mention, except in a footnote, of the absorption process, the most important recent development in this industry, nor of the later developments in transportation.

The sections devoted to refinery technology and refinery engineering are the most valuable in this work. The chapters devoted to refinery technology are full of excellent material, which has only been lightly touched upon. In fact there is enough material in these chapters for a complete volume. It is to be hoped that, when the authors come to deal with a second edition of the work, this important subject will be more fully handled. One or two points, however, strike one as worthy of remark. In our opinion it is not strictly correct to use the term "fractional distillation" in connection with distillation with the bottom steam, unless in conjunction with a fractional column or dephlegmator. Topping or stripping plants have only been casually mentioned, and we should have expected a more comprehensive review of this comparatively new yet important American development. The figures given on Oklahoma and Californian oils with regard to valuation and refining costs form a valuable basis for comparison with costs in other countries. The section on the dehydration of petroleum is one which will supply useful information to those interested in oils that are accompanied by water either in the form of an emulsion or in a free state.

The section on the "cracking process" deals fairly fully with the subject, besides giving numerous references to patents and literature, but, as is only to be expected, more space is given to methods in common use in the United States than is given to other processes. It seems remarkable that no reference has been made to one of the most successful processes now in operation, that of W. A. Hall. It is questionable whether, as claimed by the authors, the offensive odour of cracked oils is due to the presence of small quantities of sulphur compounds, naphthenic acid and basic nitrogen compounds. Rather, is it not more probably due to the inherent smell of the unsaturated compounds of the di-ene series and to the polymerized products produced therefrom? The description of the Edeleanu process is given in practically the inventor's own words. It is not stated with what success it is being used in the United States. The production of asphalt and petrolatum are adequately dealt with.

A chapter on refinery engineering is a novelty in petroleum literature, and its value can only be fully appreciated by those who have had to deal with these matters, facts being classified which otherwise entail long search and calculation. The diagrams and plates are excellent and will be of the utmost value both to the student and the expert oil refiner. Mention should be made of the chapter on hygiene and also of the suggestive chapter on "Some problems of the Petroleum Industry". On the other hand, the authors would have been well advised to omit the résumé of the shale-oil industry or to have dealt more fully with it. The glossary of bitumenology is unusual and valuable. Standardization of terminology is much needed in the petroleum industry, not only in connection with refinery technology, but also oil-field practice. It is regretted that indiscriminate use is made of the Beaumé and the scientific international standards for expressing specific gravity of oils. In our opinion, in a treatise on the American petroleum industry, specific gravity should always be expressed in terms of both standards.

A good index is attached, but it does not convey the amount of valuable information contained in the work. On the whole, great credit is due to the authors for the compilation of this treatise and for their copious references to up-to-date literature.

J. A. Leo Henderson.
E. Lawson Lomax.

British Resources of Sands Suitable for Glass-Making. By P. G. H. Boswell, D.Sc., with chemical analyses by H. F. Harwood, M.Sc., Ph.D., and A. A. Eldridge, B.Sc. Pamphlet, 92 pages; price 1s. 6d. London: Longmans, Green & Co.

This pamphlet has been published, at the instruction of the Ministry of Munitions, by the Imperial College of Science and Technology, and it contains a preface written by the Professor of Geology, W. W. Watts. Dr. Boswell began his investigations into the British sand resources over four years ago, with the support of the Imperial College, and he has personally visited a great number of deposits. Most of the samples submitted to the chemical department of the college for analysis were collected by him. During the last year his work has received Government support. Though the researches were intended as aids in glass-making, it was found that the properties of sands suitable for this purpose are so often identical with or similar to those useful in the manufacture of refractories that the original scope of the inquiries was considerably extended. The report now published is not by any means final, for the research is still being conducted vigorously.

The pamphlet covers a wide range of subjects. In the first chapter, the author describes the uses of sands in agriculture, building, water-filtration, manufacture of abrasives and refractories, glass-making, etc. In the second chapter, the geological and physiographical influences in the formation of sands are noted, and the various minerals occurring as sands or as impurities in sands are discussed. In the next chapter the author gives the physical methods of examining sands, such as screening and elutriation. In the fourth chapter an outline of glass-manufacture is given, and in the fifth the requirements of a good glass-sand are discussed, Fontainebleau sand being taken as the type approaching perfection. Chapter 6 is devoted to descriptions of a number of British deposits, and also of some of the best known deposits on the Continent. In Chapter 7, the author describes the processes adopted for improving sands found in certain deposits, and discusses possible methods for obtaining suitable sands by crushing quartzites and other rocks. The pamphlet is concluded by an exposition of the factors determining the economic value of various sands and of particular deposits.

The Portland Cement Industry. By William Alden Brown. Cloth, octavo, 160 pages, illustrated; price 7s. 6d. net. London: Crosby Lockwood & Son.

The author has had experience in cement manufacture in this country and America. The book deals with the building, equipping, and economical running of a portland cement plant, and contains chapters on physical testing.

The Prospector's Handbook. By J. W. Anderson. Fourteenth Edition. Cloth, pocket edition, 200 pages, illustrated; price 3s. 6d. net. London: Crosby Lockwood & Son.

TECHNICAL PAPERS FOR THE MONTH

British.

Colliery Guardian. — *December 1:* Mechanical Equipment of Cwm Colliery, South Wales, W. Campbell Futers. *December 8:* Ports and Coal Supplies in South America, F. J. Warden-Stevens. *December 15:* Steam-driven Winding Plant at Neumühl Colliery, Hamborn, from *Glückauf*; Combined Coal and Gas Firing for Lancashire Boilers. *December 22:* Methods of Filling worked-out Portions at the Mohpani Mines, India, from the Transactions of the Mining and Geological Institute of India; New Types of Approved Safety Lamps; The Summerlee Visual Signal for Winding Engines, D. M. Mowat. *December 29:* Stresses in Cast Iron Tubbing Segments for Vertical Shafts; Mechanical Coal-Cutting in Great Britain and United States.

The Engineer.—*December 1:* What Industry owes to Science, instancing the case of concentration by flotation; History of Channel Tunnel Projects, continued from previous issues [continued December 8, 15, 22, 29]. *December 8:* The Brunton and Beaumont English Tunnel-Boring Machines; What Industry owes to Science, in connection with smelting and metallurgy. *December 22:* What Industry owes to Science, dealing with rarer metals and with heavy chemicals and alkali; A High-lift Electrical Centrifugal Pump. *December 29:* What Industry owes to Science, referring to the sulphuric acid industry; Smelting New Zealand Iron Sand

Engineering.—*December 8:* The Cost of Swedish State Electricity; German Iron and Steel Industry during the War. *December 22:* Cheap Electric Power in Germany.

Geological Society of Glasgow. — *December 14:* Origin of Oil-Shale, H. R. J. Conacher.

Imperial Institute Bulletin. — *July-September:* Recent Work on Monazite and other Thorium Minerals in Ceylon; A New Coalfield in West Africa; Occurrence and Utilization of Antimony Ores; Occurrence and Utilization of Cobalt Ores.

Institution of Mining and Metallurgy.—*December 21:* Geology of the Insizwa Range, W. H. Goodchild.

Institution of Petroleum Technologists.—*December 19:* Geological Mapping as applied to Oil Deposits, S. Lister James.

Iron and Coal Trade Review.—*December 1:* Coal Washing Plant, Coke Ovens, and By-Product Plant at Risca Colliery, South Wales; Colliery Managers' Examination Papers; Personal Experiences of Coal Mining in North Borneo, William Hopwood, paper read before the North Wales Branch of the National Association of Colliery Managers; Vertical Retort at the Oakbank Shale-Oil Works, Scotland. *December 8:* The Coedelly Colliery, South Wales; The War and Indian Mineral Industries, H. H. Hayden, address to the Mining and Geological Institute of India; New Iron Ore Mine of the Millom and Askam Company, Cumberland, and the method of shaft-sinking. *December 15:* Electrical Experience in Collieries, C. Jones, paper read before the National Association of Colliery Managers and Association of Mining Electrical Engineers; Modern Friction Surfaces, relating to drives for winding engines, etc., John Oswald, paper read before the Association of Mining Electrical Engineers. *December 22:* Electric Safety Lamps for mines, discussion at a meeting of the Yorkshire branch of the National Association of Colliery Managers; Modernizing a Basic Bessemer Plant at Kneuttingen, Lorraine. *December 29:* Coal and Iron Trades during 1916.

Manchester Geological and Mining Society.—*December 19:* Fuel Economy, with special reference to Briquetting, F. C. A. Lantsbery.

Midland Institute of Mining, Civil and Mechanical Engineers. — *December 7:* Refractory Materials in South Yorkshire, W. G. Fearnsides; Causes of Decay in Mine Timbers, J. Mitchell.

Society of Chemical Industry, London Section.—*December 4:* Production of Nitrate of Soda in Chile, I. B. Hobsbaum.

Society of Engineers.—*December 11:* Sources of Minerals required by the Iron and Steel Industries of the United Kingdom, Professor W. G. Fearnsides; Mineral Resources of the British Empire as regards the Production of the Non-Ferrous Industrial Metals, Professor C. Gilbert Cullis.

Colonial.

Canadian Mining Institute Bulletin.—*December:* Metallurgical Notes, Alfred Stansfield; An Accounting System for Coal Mines, R. J. Maxwell; Counter-current Decantation by the Dorr System as practised at Dome Mines, Porcupine, L. B. Eames.

Canadian Mining Journal.—*November 15:* Possibility of Producing Refined Copper in Canada, A. W. G. Wilson; Gold-dredging in Yukon. *December 1:* The Weathering of Coal, J. B. Porter.

Chemical, Metallurgical, and Mining Society of South Africa Journal.—*October:* Shaking Chute for Flat Stopes, S. Nettleton; Hardening and Annealing of Metals, Professor Thomas Turner; Testing the Strength of Explosives, J A. Campbell.

Mining and Engineering Review, Melbourne.—*November:* Milling of Gold Ores, A. S. Lilburne.

South African Institution of Engineers.—*November:* Prospects for an Iudustry in Carbonization of Coal in South Africa, with By-Product Recovery, S. R. Bilborough. *December:* Notes on Bolted Timber Joints.

Foreign.

American Institute of Mining Engineers Bulletin. —*December:* Geology of the Bawdwin Mines, M. H. Loveman (some account of the author's views were given in the Magazine for March 1915).

Engineering and Mining Journal.—*November 18:* Morococha and Casapalca Districts in Peru, J. T. Singewald and B. L. Miller; The Bisulphite Process of Zinc Extraction; Zinc Mines of Tonkin; A Cadmium Myth, George C. Stone. *November 25:* Slater Copper-Leaching Process at Winona, Michigan; Pinar del Rio Copper Region, Cuba, R. H. Vail. *December 2:* A Sedimentary Magnesite Deposit, Kern County, California, L. A. Palmer; Valuation of Bedded Mineral Land, F. A. Guignon. *December 9:* The Mining Industry of Bolivia, J. T. Singewald and B. L. Miller; Chronology of Flotation, W. Motherwell; Observations on Sampling, Irving Herr; Geology of the Jerome Mining District (United Verde Copper Co.), Arizona. *December 16:* Efficiency of Compressed Air Installations, T. Simons; Reduction of Stope Contours, J. J. Bristol; Launder Flotation Machine, B. M. Snyder; Huayni-Potosi Bismuth-Tin Mines, Bolivia, B. L. Miller and J. T. Singewald,

Journal of Geology. — *November-December:* Inorganic Agencies in the Deposition of Calcium Carbonate, J. Johnston and E. D. Williamson; Structural Relations of Australasia, New Guinea, and New Zealand, E. C. Andrews; Effects of Capillarity on Oil Accumulation, A. W. McCoy; Deposition of Sulphur at Kunashiri Volcano, Japan, Y. Oinouye; Contributions to the Study of Ripple Marks, D. W. Johnson.

Metallurgical and Chemical Engineering. — *November 15:* Minerals Separation versus Hyde, arguments in the Supreme Court at Washington; Analysis of Tank Resistance in Electrolytic Refining, Lawrence Addicks; Proper Current Densities in Electrolytic Refining, B. B. Hood; Recent Developments in Scientific Instruments and Materials, E. Schramm, paper read before the American Electro-chemical Society; Chemical and Physical Properties of Foundry Irons, J. E. Johnson [continued December 1 and 15]. *December 1:* Proposed Method of Making Potassium Chloride, Anson G. Betts. *December 15:* Electrolytic Oxidation of Sulphurous Acid, M. de K. Thompson and N. J. Thompson; Determination of Nickel in Iron Ore, P. Covitz; Utilization of Waste Heat for Steam-Raising Purposes, A. D. Pratt.

Mining and Scientific Press.—*November 11:* The Britannia Mine and Mill, British Columbia, T. A. Rickard; Extra-Lateral Right, Shall it be Abolished? W. E. Colby; The Prospector's Field-Work, Herbert Lang; Ore-Sampling Conditions in the West, T. R. Woodbridge. *November 18:* Importance of Efficient Settlement of Slime, P. W. Avery. *November 25:* The Blue Bell Mine, British Columbia, T. A. Rickard; Flotation at the Calaveras Copper Co.'s Mine, California, H. R. Robbins; Strontium Nitrate produced from Celestite obtained from Imperial Valley, California, D. F. Irwin. *December 2:* Lead Mines of Washington County, Missouri, S. H. Ball: Flotation Oil from Sage Brush; Black Sand of the Pacific Coast, Herbert Lang.

Mining and Engineering World.—*November 18:* Advancement and Present Status of Preferential Flotation, H. J. Stander; Pardee's Centrifugal Ore Separator. *November 25:* Annual American Mining Congress. *December 2:* Sulphidizing Carbonate Tailing at Panaca, Nevada, W. A. Scott; Daily Sampling in Square-set Mining, F. B. Hanchett; The Hulett Unloader at the New Cornelia Copper-Leaching Plant; Leaching Iron from Tin Ore, as practised at Steglitz, Germany. *December 9:* Gold-Mining Operations in Korea, E. W. Mills.

YEARLY REPORTS OF MINING COMPANIES

Sulphide Corporation.—This company was formed in 1895, as the Sulphide Corporation (Ashcroft's Process) Limited, to purchase the Central mine at Broken Hill, and to treat the ores by E. A. Ashcroft's leaching and electro-deposition process. On this process not proving suitable, mechanical concentration was adopted for extracting lead concentrate; and subsequently the Minerals Separation processes were applied for treating the zinc tailing and the slime. A lead-smelter was erected at Cockle Creek, New South Wales. Most of the zinc concentrate was sold to German buyers. A subsidiary, the Central Zinc Co., was formed to smelt some of the zinc concentrate at Seaton Carew, Durham. This subsidiary has been re-absorbed recently, as recorded in our issue of June last. The report of the corporation for the year ended June 30 last shows that, as with the other Broken Hill companies, operations were suspended for five weeks by a strike at the beginning of 1916, and that for several weeks afterward the mine and plant were worked on short time. The amount of ore raised was 181,992 tons, of which 177,449 tons, averaging 15·9% lead, 18% zinc, and 12·9 oz. silver per ton, was sent to the lead mill, together with 7,021 tons from the Junction mine, averaging 11·3% lead, 7·5% zinc, and 10·4 oz. silver per ton, making a total of 184,470 tons. In the lead mill there was recovered 35,925 tons of lead concentrate, averaging 64·4% lead, 8·4% zinc, and 37·7 oz. silver. In the zinc flotation plant, and in the subsequent de-leading of zinc concentrate, there were produced 56,773 tons of zinc concentrate, averaging 47·5% zinc, 6·3% lead, and 13·6 oz. silver, and 1,578 tons of lead concentrate, averaging 57·7% lead, 15·4% zinc, and 45·2 oz. silver. At the Cockle Creek smelting works, purchased ores, some of which were gold ores, were treated as well as the corporation's lead concentrate, the total put into the furnace, including by-products, being 106,256 tons. The yield was 34,083 tons of lead bullion, containing 36,759 oz. gold and 2,750,783 oz. silver. The shipments of zinc concentrate totalled 59,689 tons. At the producer-gas plant at the smelter, 796 tons of sulphate of ammonia was recovered, and also 153,085 gallons of tar, the latter at present being used as fuel. The sulphuric acid plant produced 10,168 tons of acid, and the superphosphate plant produced 15,930 tons of fertilizer. The superphosphate plant and the smelter at Seaton Carew are being extended; the remodelled zinc concentrator was started in October 1915; a small plant for the production of electrolytic zinc from ore, slag, etc., is being built; and a refinery for the lead bullion is under construction. No development has been done recently; the reserve of ore is estimated at 1,858,200 tons. The accounts show a working profit of £771,308, out of which £368,538 has been paid as, or set aside for, taxes of various kinds. The dividends absorbed £315,000, of which £180,000 went to the preference shares and £135,000 to the ordinary shares, being 30% in each case. C. F. Courtney is general manager of the company, James Hebbard is manager at Broken Hill, and F. H. Evans is manager at Cockle Creek.

British Broken Hill.—This company was formed in 1887 to purchase Blocks 15 and 16 from the Broken Hill Proprietary. The property has not been one of the most successful of the Broken Hill group of lead-zinc-silver mines. The original capital has been scaled down, and additional capital has twice been subscribed. On two occasions operations were suspended owing to the low price of metals; and work also ceased on the outbreak of war. In 1912 a new orebody was discovered, but its assay-value is no higher than that of the main lode. The report for the half-year ended June 30 shows that 3,599 tons of carbonate ore, averaging 25% lead and 7·38 oz. silver, was extracted from the upper levels. The remaining stock of lead concentrate, 2,238 tons, left over on the outbreak of war, was sold to Japanese buyers, and 13,963 tons of stored slime was delivered to the Junction North company. The income from the sale of ore and concentrate covered the costs during the period. Arrangements have recently been made to reopen the mine. The lead concentrate will be sent to Port Pirie, the company taking £30,000 in shares in the Broken Hill Associated Smelters; while the zinc concentrate will be sold through the Zinc Producers Association. The directors do not disguise their opinion that better terms for the disposal of their lead product could have been obtained elsewhere, but their alternative proposal was vetoed by the Commonwealth Government.

Rambutan.—This company belongs to the Wickett group at Redruth, and was formed in 1905 to work an alluvial tin property in the northern part of the Kinta district of Perak, Federated Malay States. Osborne & Chappel are the managers. A suction dredge was used at first, but ordinary sluicing was substituted later. The report for the year ended June 30 shows that 607,000 cubic yards was treated for a yield of 215 tons of tin concentrate. The production per yard was 13 oz. worth 8·6d., and the working cost was 3·7d. The output was rather less than that of the year before, owing to poor ground being worked. Since June 30 the yield per yard has improved again. The accounts show receipts from the sale of concentrate amounting to £21,786, and a net profit of £11,395, out of which £10,000 has been distributed as dividend, being at the rate of 10% free of tax.

Chendai Consolidated.—This company belongs to the Wickett group at Redruth, and was formed in 1914, as a consolidation of the Redhills, Sungei Chendai, and Chendai Lodes companies, operating gravel and lode tin mines in the Kinta district of Perak, Federated Malay States. The report for the year ended April 30 shows that the stamp-mill, consisting of 4 Holman stamps, at Chendai was not completed until December. From the start to the end of April, 3,588 tons of ore was crushed for a yield of 24 tons of tin concentrate, equal to 15 lb. per ton. The results have been disappointing owing to the only stope available at present being in a poor zone. Lack of capital, and the difficulty of obtaining supplies of explosives, have greatly hampered progress. Tributers continue to be employed in the Katcha and Chendai sections, and during the year produced 145 tons of concentrate. The company's profit from the proceeds was £1,103. The accounts for the year show a slight loss.

Kinta Tin Mines.—This company was formed in 1900 to acquire alluvial tin properties on the eastern side of the Kinta valley, Perak, Federated Malay States. W. A. Luning is chairman, and Osborne & Chappel are the managers. Satisfactory dividends have been paid continuously. About three years ago it became necessary to seek additional water-supply at higher pressure, and a new installation was arranged, conjointly with the Gopeng company, bringing water from the Kampar river. The report for the year ended June 30 shows that 915,000 cubic yards of ground was worked for a yield of 476 tons of tin concentrate, selling for £48,067. The yield per yard was 1·16 lb., and the working cost 4¾d. The profit, after allowing for depreciation and taxes, was £22,421, out of which £19,800 has been paid as dividends, being at the rate of 17½%. During the previous year, the output of tin concentrate was 254 tons, so that the new water-supply has proved its value.

Northern Nigeria (Bauchi) Tin Mines.—This company was formed in 1910 to acquire alluvial tin properties at N'Gel in Nigeria from the Anglo-Continental Mines Co. Interests have also been taken in the Gurum River, Jantar, and Cornish Tin Sands companies. Small dividends were paid in 1912 and 1913 on the 252,563 preference shares of 10s. each, and a dividend of 10% on these shares has been declared for the year ended June 30 last. Nothing has at yet been distributed on the 194,453 ordinary shares of similar denomination. Tin-winning was started by calabashing, but sluicing was adopted later. Gravel pumps have been installed recently. The report for the year ended June 30 shows that 565 tons of tin concentrate was recovered as compared with 314 tons the year before, and that 559 tons was sold for £67,754. The net profit was £16,481, out of which £12,628 has been paid as dividend on the preference shares. A. R. Canning, the manager, describes the prospecting and testing work done during the year. He is of opinion that the ground proved during this time will yield 1,183 tons of concentrate, bringing the total content of proved ground to 3,340 tons.

Naraguta (Nigeria) Tin Mines.—This company was formed in 1910 to acquire alluvial tin ground at Naraguta, Northern Nigeria. Other properties have since been acquired, at Karama in the Ninkada district, and at Sho, near Zungeru. F. N. Best is chairman, C. G. Lush is consulting engineer, and F. O'D. Bourke is manager. The report for the year ended March 31 last, just issued, shows a further fall in the output, the aggregate being 580 tons, as compared with 651 tons the year before, and 887 tons two years ago. Of the total, 422 tons came from Naraguta, 85 tons from Sho, and 72 tons from Karama. The cause of the fall is the lower tin content of the ground now being worked. On the other hand, the new pipe line has substantially reduced the costs at Naraguta. The income was £53,546 and the profit £14,326. This profit was carried forward, but since the end of the company's year two dividends at the rate of 5% each have been paid, £17,500 being thus distributed. During the year additional leases have been obtained at Naraguta and Karama. The new areas at Naraguta are not easy to work and are of low grade. Ground is being examined at Hepham, in the South Bukeru district.

Pahang Consolidated.—This company was formed in 1887 as the Pahang Corporation to acquire lands containing tin lode-mines in the State of Pahang, Federated Malay States. In 1906 the properties of the Pahang-Kabang and Malayan Exploration companies were absorbed, and the name was then changed, and additional capital subscribed. In 1909 the scale of development was expanded, on the advice of William Frecheville, and further funds were provided for this object. The results obtained by the company since then have been excellent. The report for the year ended July 31 last shows that 162,200 long tons of ore was raised and treated, yielding 2,535 tons of tin concentrate. In addition 112 tons was won from alluvial deposits by tributers. The profit for the year was £98,924, out of which £18,984 has been written off plant and shaft-sinking accounts and £10,000 placed to reserve. The dividends absorbed £68,155, being 12% on £100,000 preference shares and 15% on £374,370 in ordinary shares. At the chief property, Willink's mine, both of the shafts have been sunk deeper, Willink's to 982 ft., and Nicholson's to 1,348 ft. below surface. A very large amount of development has been done at all the properties, the total during the year being 46,805 ft. Owing to the ore occurrence being irregular, it is difficult to give actual figures for the reserve, but J. T. Marriner, the manager, estimates it at a two years' supply. Of the other properties, the Gunong is the most promising. The lodes here have only recently been discovered, but a large amount of development has already been done.

St. John del Rey.—This company was formed in 1830 to work the Morro Velho gold mine in the State of Minas Geraes, Brazil. Since 1888 the management has been in the hands of George Chalmers, who reopened the mine after a previous serious collapse. The orebody is in ancient schists, and descends in a vertical plane with a pitch of 45° in the upper portions, gradually becoming flatter below the 17th horizon. In horizontal section the orebody is about 1,000 ft. long and 20 ft. thick. The interim report for the half-year ended August 31 last shows that 101,429 tons of ore was raised, and 94,300 tons sent to the mill. The yield of gold was worth £231,332, being an extraction of 49s. per ton. Of the yield per ton, 34s. 6d. was obtained on the blankets, and 14s. 6d. by cyanide. The working cost was £145,163, £13,970 was paid as taxes, etc., and £20,000 was allocated to capital expenditure. The preference shareholders receive £5,000, being at the rate of 10% per year, and the ordinary shareholders receive £20,485, being at the rate of 9d. per £1 share, or 7½% per year. The yield per ton was the highest since the reopening of the mine in 1888. It will be remembered that cross-cuts were driven from "G" shaft at the 19th and 20th horizons simultaneously, in order to test the lode at depth, at 5,526 ft. and 5,826 ft. vertically, respectively, before any proposal for additional equipment or further sinking was considered. On the 19th horizon, 992 ft. has been driven on the lode, which has been proved to be equal in value to anything in the levels immediately above. On September 14 of this year the cross-cut on the 20th horizon intersected the lode, and, according to cable advice, 450 ft. has been driven on it, the ore being proved here also to be of excellent quality. The ventilation of the mine is being improved in order to reduce the heat in the lower workings. As we have on several occasions, particularly in our issues of July 1911 and June 1912, recorded, the heat at the bottom of this mine is great, and the problem has engaged Mr. Chalmers' close attention for some years.

Champion Reef.—This company was formed by John Taylor & Sons in 1889 to acquire gold-mining property adjoining the Mysore mine on the north, at Kolar, Mysore State, South India. The prosperity of the mine was great, and the output expanded continuously, from the outset until 1910. Since then the grade of the ore has been about 11 dwt. per ton, as compared with 1 oz. in 1906 and 1½ oz. in 1900. During the past year developments have been disappointing, and decreases in output of ore and in grade are foreshadowed. Rock-bursts have also caused trouble in the lower levels, and part of the mine has had to be closed while a system of close-filling is inaugurated. The report for the year ended September 30 last shows that 194,311 tons of ore was treated, yielding 97,563 oz. of gold, these figures showing decreases of 17,057 tons and 8,612 oz. gold as compared with the year before. At the cyanide plant, 285,493 tons of current and accumulated tailing was treated for a yield of 20,231 oz. gold, the decrease being 34,926 tons and 2,754 oz. The total yield of gold was worth £497,329. The royalty was £27,437, the working cost £305,689, taxes £28,454, allowance for depreciation £18,000, expenditure on shaft-sinking £11,583, and £11,000 placed to reserve and contingency funds. The shareholders received £104,000, being at the rate of 40%. Owing to unfavourable developments in depth, the ore reserve has fallen by 119,024 tons, and now stands at 375,991 tons. It is expected that the monthly returns will be further reduced during the next few months. In the meantime, the auxiliary shafts in the Carmichael and Glen sections are being sunk, with the object of testing the lode at greater depth.

Frontino & Bolivia.—This company was formed in 1864 to acquire gold mines in Colombia, South America. It was reconstructed in 1886, and again in 1911. On the latter occasion, Pellew-Harvey & Co. made several recommendations for development at depth and for improved metallurgical methods. The report now issued covers the year ended June 30 last. During this time, 20,594 tons of ore was raised from the Silencio mine. The ore treated in the mill was 25,484 tons, and the yield of gold was 22,329 oz. worth £96,359. The profit was £24,488, out of which £4,513 has been paid as debenture interest, at the rate of 10%. The preference shares received £2,339 or 10%, and the ordinary shares £14,000, also at the rate of 10%. The main shaft has been sunk to the 15th level, and the station is being cut. Development on the 14th level has been conducted actively, and 460 ft. has been driven so far. The ore reserve is estimated at 42,200 tons, averaging 20 dwt. per ton, as compared with 34,000 tons the year before. The cyanide plant was completed early in 1916, but owing to shortage of power, was not fully at work until September. A separate company has been formed to acquire the Marmajite Cogote property, but the consent of the Treasury had not yet been obtained. The first unit of the new electrical power plant was started in October.

Chinese Engineering & Mining.—This company was formed in 1900 to acquire coal mines at Kaiping, Chi-li, North China, and was reconstructed in 1912 for the purpose of removing marketing difficulties between the company and another colliery company operating adjoining lands and controlled by Chinese owners. The businesses of the two companies are now directed by a body called the Kailan Mining Administration. The report for the year ended June 30 shows that the collieries under the control of this Administration sold 2,667,743 tons, at a profit of $3,177,538, 60% of which came to this company. The net profit of the company as shown in the London accounts was £195,145, out of which £100,000 was distributed as dividend, being 10% free of income tax. Major Nathan, the manager, reports that the reserve developed at the mines is 16,344,000 tons. The electric power service has been partly erected; the remainder should be completed during the present year.

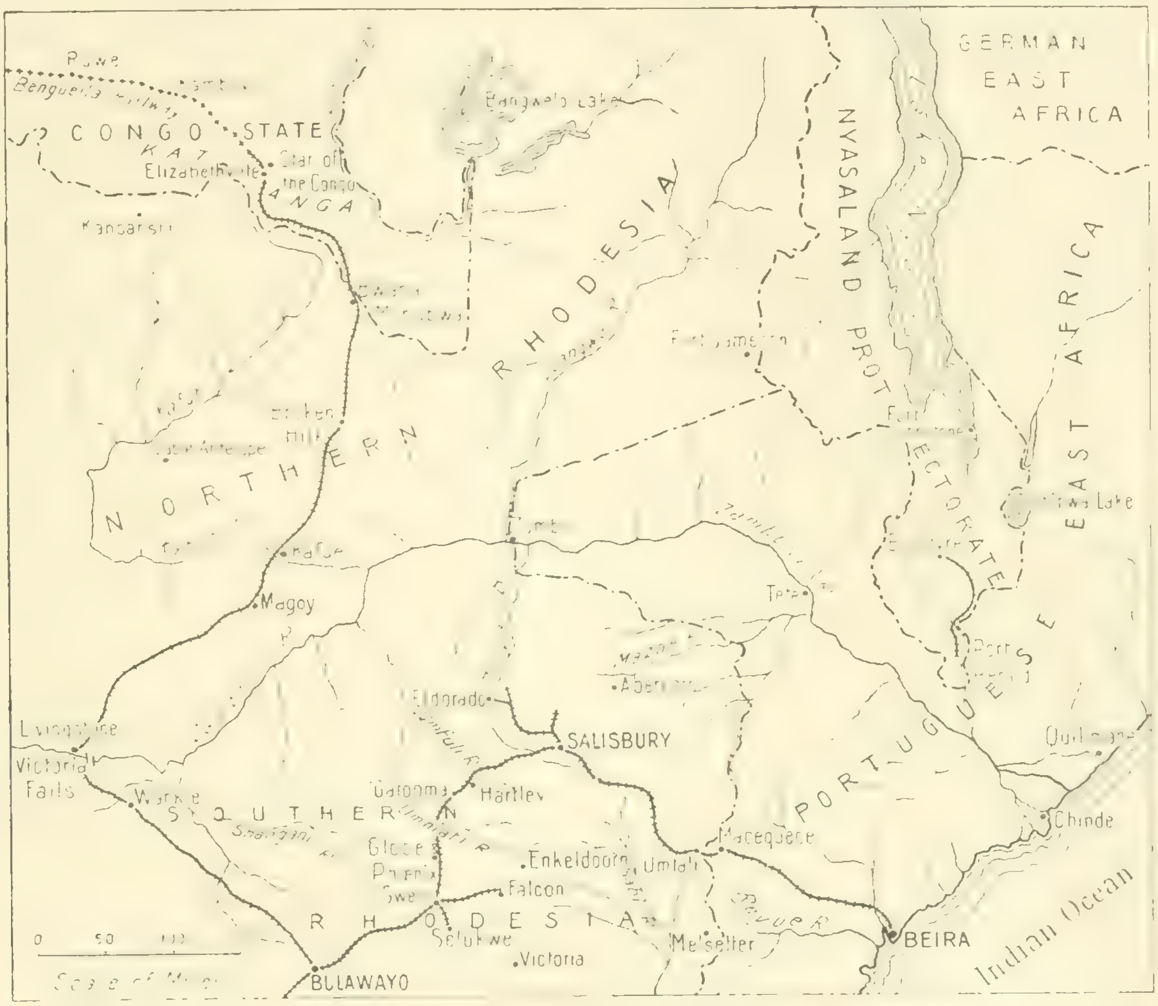
San Miguel Copper Mines.—This company was formed in 1904 to acquire a pyrite mine in the south of Spain. The directorate was changed in 1907, and the control is now in the same hands as the Pena. The new board had to reorganize the finances drastically. Small dividends were paid in 1912 and 1913. The report for the year 1915, only just published, shows that 26,834 tons of ore was raised, as compared with 51,206 tons in 1914, and 75,265 tons in 1913. Of the output, 13,757 tons was sent to the leaching floors and 13,077 tons was sold for export. The fine copper contained in the precipitate obtained by leaching was 425 tons. The deliveries of washed ore were 25,599 tons. The accounts show a loss on the year's working of £1,835. The fall in the amount of ore raised is due to the development having being neglected. Additional plant has been provided for the purpose of remedying this state of affairs. The company has been continuously a sufferer from a long-term contract for the sale of washed ore made by the original directors, with the result that this ore yields little or no profit. Of recent years the copper content of the ore sent to the leaching floors has fallen, so that the realizable value of the ore is less than its actual cost. The board has, therefore, found it necessary to write down the book value of the heaps by no less than £31,511, In order to do this, the reserve of £25,000 has been extinguished, and the remainder written off the balance to the credit of profit and loss.

Camp Bird.—This company was formed in 1900 by F. W. Baker and John Hays Hammond to acquire, from Thomas F. Walsh, the Camp Bird gold mine in Ouray county, Colorado. After yielding handsome profits for ten years, the mine began to show signs of ore-impoverishment in the lower levels, and the directors turned their attention to other properties. The Santa Gertrudis silver mine, at Pachuca, Mexico, was acquired and a separate company was floated to work it. Also investments were made in debentures in the Messina company, which works the copper mine in the northern Transvaal. The report for the year ended June 30 last shows that the ore reserve was exhausted and the hoists stopped running on the 12th of that month, and that the stamp-mill ceased operations on the 24th. During the year, 25,601 short dry tons was treated for a yield of gold worth $723,421, and of silver worth $48,441; in addition $19,887 was received for copper and lead constituents in concentrates, making the total yield $791,749, or $30·92 per ton. The net profit was £93,210, out of which £14,304 has been paid as income tax, and £467 paid as extra remuneration to the directors. The preference shareholders received £45,473, being at the rate of 7%; the 1,100,051 ordinary shares of £1 each received no dividend, the surplus funds being required for further development. As announced in our issue of January a year ago, it was decided to develop the ground below No. 3 shaft by means of an adit estimated to reach the lode at a point 450 ft. below the 9th level, and at a distance of about 10,700 ft. from the mouth of the adit. Up to October 30 this adit had been driven 2,944 ft. In the course of this driving, four narrow veins have been cut, one of them being high in lead. H. C. Hoover has recently resigned the position of chairman of the company, which he had held since the retirement of A. M. Grenfell two and a half years ago.

Santa Gertrudis.—This company was formed in 1909, under circumstances narrated in the foregoing paragraph, to acquire a silver mine at Pachuca, Mexico. The report for the year ended June 30 shows that the mine and mill have been worked continuously during the period, in spite of the revolutions and shortage of supplies, though the rate has varied greatly, from 20 to 80% of the normal. It will be remembered that operations were entirely suspended from April to June 1914. The amount of ore treated during the year was 227,616 dry tons, and the extraction was 12,550 oz. of gold and 2,286,450 oz. of silver, worth £352,506, being a yield of 31s. per ton. The net profit was £41,637, which with £55,393 brought forward from the previous year gave an available balance of £97,030. Out of this, £75,000 has been distributed as dividend, being at the rate of 5%. Development in depth during the year has disclosed little ore of value. The auxiliary shaft, started on the 19th level, has been sunk further, and a 22nd level opened. The work on this level has not been encouraging so far. Additions to the reserve have come from the intermediate lode, and from a new orebody in the hanging wall of the main lode extending from the 14th to the 16th levels. The reserve is estimated at 1,214,000 dry short tons averaging 1·2 dwt. gold and 13 oz. silver per ton, as compared with 1,287,000 tons of similar tenor a year ago.

Wankie Colliery.—This company was formed in 1899 to develop coal deposits in Southern Rhodesia, between Bulawayo and Victoria Falls. The control is with the British South Africa Co., Edmund Davis is chairman and managing director, and A. R. Thomson is manager in Rhodesia. At first the venture was a comparative failure, and in 1909 the shares had to be written down from £1 to 10s. Subsequently prosperity arrived, and the capitalization was restored to its old level by giving two 10s. shares for each one previously held. An important accession of business came from the Union Miniere du Haut Katanga. The report for the year ended August 31 shows that the output continues to increase. The coal sold amounted to 304,628 tons, 75,759 tons was used for coke-making, and 13,426 tons was used for power purposes and in the brick-making plant. During the same period 45,964 tons of coke was sold. The first coke ovens were of the bee-hive type. Plant of the retort type was more recently adopted, and this started work in June last. The accounts show receipts of £192,167 and a profit of £63,030, of which £5,300 was paid as debenture interest, and £50,654 as dividend, being at the rate of 12½%. We described the Wankie coal deposits in our issue of May 1914.

Cam and Motor Gold Mining.—This company belongs to the London & Rhodesian Mining & Land group, which is controlled by J. & S. Weil, and was formed in 1910 to acquire gold mines at Gatooma, in the Hartley district of Rhodesia. Attention has been centred on the Motor section, and the Cam and Good Shepherd sections have been sold to the Giant company, a member of the same group. The ore is mostly pyritic and contains antimony and arsenic, but as recorded in our issue of May last, a branch vein discovered on the 7th level contains coarse free gold. The report for the year ended June 30 last shows that 143,318 tons of sulphide ore and 13,710 tons of oxidized ore was treated by roasting and cyaniding, for a yield of 51,669 oz. In addition 5,894 tons of accumulated slime gave 512 oz., and old slags 571 oz. The total yield was worth £219,374. The working cost was £202,841, debenture and other interest £4,216, and administration expenses £2,155. The balance of profit was £8,561, but this is subject to provision for depreciation. John McDermott, the manager, estimates the ore reserve at 577,281 tons, averaging 36s. 6d. per ton, as compared with 739,844 tons averaging 41s. 5d. the year before. The reasons for the fall are that some parts of the veins are narrower than originally expected, and that many of the richer stopes are found to include stretches of lower-grade material. Little development has been done during the year. The appearance of free gold has made it necessary to modify the treatment plant, by the addition of grinding pans and amalgamating tables. During the past year



MAP OF RHODESIA, SHOWING WANKIE AND GATOOMA (CAM & MOTOR).

the percentage of recovery was 83 per cent.

Giant Mines of Rhodesia.—This company belongs to the same group as the Cam & Motor, and was formed in 1903 to acquire a gold mine 60 miles west of Salisbury. Two years ago the ore showed signs of exhaustion, and the Cam-Good Shepherd claims were acquired from the Cam & Motor company. These claims are now being developed. The report for the year ended June 30 last shows that 80,602 tons of Giant ore yielded gold worth £52,617, at a working profit of £18,207. The reserve fund is £40,000, which will be devoted to the development of the Cam-Good Shepherd, where the reserve is estimated at 130,636 tons averaging 43s. per ton. Some of this ore has been delivered to the Cam & Motor mill where it is treated on a royalty basis. John McDermott is manager.

Sheba Gold.—This company was formed in London in 1887 to acquire from a local company a group of gold-mining properties at Barberton, in the eastern Transvaal. Dividends were paid from 1891 to 1898, but then came a series of disappointing years. The company was reconstructed in 1904 and 1911, on the latter occasion the capital being reduced from £1,078,954 to £269,738 by writing down the par value of the shares from £1 to 5s. Dividends were resumed in 1911 and continued until 1915. The report for the year ended June 30 last shows a diminution of profit owing to the lower grade of the ore treated, and a serious reduction of the reserves and their assay-value. During the year, 83,125 tons averaging 9·2 dwt. per ton was raised and treated ; of this, 30,840 tons averaging 8·8 dwt. came from the Zwartzkopje, 40,446 tons averaging 8·48 dwt. from the Intombi, 3,805 tons averaging 7·48 dwt. from the Southern Cross, 7,483 tons averaging 16·1 dwt. from the Insimbi, and 551 tons averaging 5·4 dwt. from the Royal Sheba and Great She. During the previous year 84,910 tons averaging 10·34 dwt. was milled. The yield of gold by amalgamation and cyanide was 27,703 oz. worth £117,004, as compared with 33,921 oz. and £143,564 the year before. The profit for the year was £11,610, which was carried forward. J. T. Milligan, the manager, reports that throughout the year there has been little or no ore reserve at Zwartzkopje, the figure on June 30 being estimated at 7,400 tons averaging 5 dwt. Proportionally more ore was drawn from the Intombi, but here again the reserve has not been fully maintained, standing on June 30 at 40,500 tons averaging 8 dwt. This ore contains more sulphide than that at Zwartzkopje, and it has been necessary to provide additional concentration plant. At the other mines, there is a reserve of about 53,000 tons averaging 7 dwt., but the outlook is not particularly hopeful at any of them.

Luipaard's Vlei Estate & Gold.—This company was formed in 1888 by the Consolidated Gold-Fields to work a gold mining property in the far west Rand. Milling was started in 1898, and after the Boer war, was not resumed until 1906. In 1909 the adjacent Windsor mine was absorbed. Small dividends were distributed in 1908 and 1909, and the payment of dividends has just been resumed. The control passed to L. Ehrlich & Co. in 1912, who appointed C. B. Saner manager. The property consists of four sections, two on the Main Reef Series, and two on the Battery Reef to the south. The report for the year ended June 30 last shows that 334,120 tons was mined, and after the rejection of waste, 256,005 tons was sent to the mill. The yield of gold was 67,789 oz. worth £282,660, being 5·3 dwt. or 22s. per ton milled. The working cost was £243,482 or 19s. per ton, leaving a profit of £39,117 or 3s. per ton. The directors have paid a dividend of 3¾% for the year ended June 30, 1915, absorbing £17,700, and two dividends of 2½% each, or 5% together, for the year ended June 30, 1916, absorbing £23,600. The tonnage milled was 37,552 tons higher than for the year before, and the yield per ton was 2s. 2d. more. About 77% of the ore milled came from the Main Reef Series. The development during the past year gave good results in all sections. The reserves on June 30 were estimated at 826,138 milling tons averaging 5·67 dwt., an increase of 124,015 tons and 0·37 dwt., as compared with the previous year. During the year 28 claims were acquired adjoining the Windsor section from the liquidators of the French Rand Gold Mining Co. These claims extend for 750 ft. eastward along the strike. Development of this area has been commenced from the 14th level in the Windsor section.

Knights Deep.—This company belongs to the Consolidated Gold Fields group, and was formed in 1895 to acquire property on the dip of the Glencairn and Knights in the middle east Rand. In 1913 an amalgamation was effected with the Simmer East, the two companies having previously been worked conjointly as to both management and milling accommodation. The ore is of low grade, but as the stopes are wide, mining is comparatively cheap. The report for the year ended July 31 last shows that 1,307,300 tons was raised, and sent to the mill without sorting. The yield of gold by amalgamation and cyanide was 238,846 oz., worth £994,969, being 15s. 2d. per ton. The working cost was £797,026, or 12s. 2d. per ton, leaving a working profit of £197,942 or 3s. per ton. Taxes, etc., absorbed £32,639, and £24,722 was applied to redemption of debentures and capital expenditure. The shareholders received £111,528, being at the rate of 15%. The tonnage milled was 134,380 tons greater than during the previous year, owing to more labour being available, and the working profit was £32,831 higher. The ore reserve is calculated at 2,614,000 tons averaging 4·4 dwt. per ton, figures approximately the same as last year. Ore is extracted also by reclamation, but no estimate of the resources in this direction is possible. G. A. Chalkley is the manager.

Van Ryn Gold Mines Estate.—This company was formed in 1892 to acquire property on the outcrop in the Far East Rand, being in fact the pioneer in the development of this section of the Rand. The assay-value of the ore has always been less than that in the central Rand, and also less than that of many parts in the deeper levels of the Far East Rand. It was not until 1904 that dividends were paid. Sir George Albu is managing director, and E. G. St. John is manager. The report for the year ended June 30 last shows that 500,436 tons of ore was raised, and after the rejection of 8% waste, 460,310 tons was sent to the stamps. The yield of gold by amalgamation was 92,324 oz. and by cyanide 40,339 oz., making a total of 123,662 oz. worth £555,230, being 5·76 dwt. or 24s. 1d. per ton milled. The working cost was £344,994 or 15s. per ton, leaving a working profit of £210,236 or 9s. 1d. per ton. Out of this profit, £175,000 was distributed as dividend, being at the rate of 35%, while £25,579 was paid as profits tax and £8,579 as war levy. As compared with the previous year, the working profit was £25,461 lower, owing chiefly to a fall of 11d. per ton in the grade of the ore. The ore reserve has been fully maintained, standing at 1,950,191 tons, averaging 6·7 dwt. per ton. As compared with the previous year, the assay-value of the reserve is nearly 0·5% higher. Sand-filling of the old stopes was commenced a year or more ago, and it is expected that reclamation of old pillars on an extensive scale will be possible shortly.

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CONTENTS.

EDITORIAL

SPECIMENS of tungsten ores from the Malay Peninsula are on exhibit at the Imperial Institute. These will help to illustrate articles recently published in the Magazine, notably those by Mr. Henry Brelich on the Trengganu mines, appearing in our issue of November 1915, and by Mr. J. B. Scrivenor on occurrences of wolfram and scheelite in the Federated Malay States, in the issue of June last.

STAPLE trades of this Empire form the subject of a series of weekly lectures now being given at the London School of Economics and Political Science. Last week the subject was "Metals as the Base of Imperial Strength," and the lecturer was Mr. Octavius C. Beale, Chairman of the Sydney Chamber of Commerce. This school is under the control of London University, and it was endowed by the late Mr. Passmore Edwards, a London newspaper proprietor of lofty aim and sound performance.

WITH unusual pleasure we welcome a new contemporary, the *Magazine* of the Federated Malay States Chamber of Mines, the first issue of which, dated December, is just to hand. It is published at Ipoh, Perak, and the editors are Messrs. C. Pearse and A. H. Flowerdew. Besides being the official organ of the Chamber, the journal will provide a chronicle of mining events in the Malayan Peninsula. The contents of the first number include Mr. A. C. Perkins's paper on dredging in Malay, which we quoted in abstract in our last issue, together with a report of the discussion at the meeting, and written contributions. In particular, the remarks of Messrs. Malcolm Newman and T. R. A. Windeatt are illuminating. Other articles of interest are those describing the installations at French Tekka, Malayan Tin, and Malayan Collieries. Tables are given of all the producing mines, with information as to output, capital, and dividends. The editors disclaim professional efficiency as such, but they more than compensate for any deficiency in this respect by presenting excellent technological matter. Now that Malayan mining is attracting such keen attention in this country and Australia, the appearance of a public disseminator of information is timely.

WE stated in our personal column in November that Mr. H. C. Woolmer was to be appointed managing director of the Spassky Copper Mine, Limited. A bald announcement from the London manager and secretary of the company contradicting our paragraph was published in the following issue. In amplification we wish to say that Mr. Woolmer has been manager of the company's mines in Siberia for nine years, and that a year or more ago he gave notice terminating his engagement with the company, as he was unwilling to give his sole attention to its affairs, after such a long residence in Russia. When we inserted the note in the Personal column, there was some probability that his connection with the company would be continued in some other capacity. No such arrangement, however, proved possible, and the long association consequently came to an end.

FOLLOWING on our editorial last month on de-tinning schemes, we are informed that Mr. Morgan L. Jones's committee of five has recommended that a trial plant on a small scale should be erected. The consent of the Ministry of Munitions has been obtained, and the method is to be tried in South London. We hear that the borough of Hornsey, in the north of London, has recently added a "de-tinning" plant at its refuse destructor. The old cans are placed in the flue through which the destructor gases go on their way to the chimney. A good deal of solder is recovered in this way.

IN OUR issue of November we mentioned that the directors of Prestea Block A had taken action against an "assayer" on their staff for illegal possession of gold bullion belonging to the company, and that they had secured a conviction in a London police court. We are informed that the delinquent was not an assayer, but a shiftman in the reduction works. We apologize to the real assayers for an unintentional oblique reflection on their integrity. Many honourable professions and businesses are indirectly libelled by the claim to their status on the part of people who get into trouble.

OUR Chicago contemporary, the *Mining and Engineering World*, has been absorbed by the *Engineering and Mining Journal*. During its twenty-two years of existence, it never attained high professional standing, though its pages often contained useful information. By far the best work done by the paper was the Index of Current Literature, which, being published weekly, and rearranged and reprinted in half-yearly bound volumes, was of great service in research.

IN addressing the shareholders of the London, City, & Midland Bank Sir Edward Holden made an interesting statement relating to the financial condition of Germany. It has been said in many quarters that the weekly returns of the Reichsbank are grossly falsified, that the banking and commercial position in Germany is tottering, if not actually in a state of collapse, and that the successive loans are unrealities. In the midst of so much misinformation and guess-work, it is well to have a public statement by an expert in finance, giving some calm views on these matters. From his remarks it would appear that the chief inconvenience so far felt in German financial circles has arisen from the difficulty of maintaining a gold reserve against a greatly expanded paper currency, and even this trouble might not have arisen had the cheque system been as widely prevalent as in this country. On the same occasion Sir Edward gave a dissertation on the theory of credit as established in this country, and also an account of recent attempts in America to avoid financial crises and to regulate foreign exchange. His speech constituted, in fact, a valuable contribution to the literature relating to the present conditions in political economy, and it might to advantage be printed and widely circulated.

Development of Southern China.

The mineral resources of Southern China once more receive attention in our pages. We present this month an article, written by Messrs. A. S. Wheler and S. Y. Li, describing an important lead-zinc mine in Hu-nan, which is equipped with modern dressing-plant. The chief value of this article is that it gives complete information as to costs of operation.

SKETCH MAP OF PART OF SOUTHERN CHINA.

As Mr. Wheler has recently held the position of mining adviser to the Chinese Government, he has had unequalled opportunities for obtaining correct information. The mine in question is situated 90 miles south of Heng Chow, and its means of communication is by river northward to the Yangtze. In this connection it is of interest to mention that the mine is on or near the route of the projected railway from Heng Chow to the Gulf of Tonkin at Yam-chow. This railway forms the subject of one of the recent contracts made by the Chinese Government with the American firm of contractors, Siems & Carey. As the proposed route has not yet been surveyed, its exact location is not actually fixed, nor is it even certain that the engineering conditions are favourable. We believe that many difficulties will be encountered in following the valleys on both sides of the boundary between Hu-nan and Kwang-si. These are not insuperable, but the question of cost has to be considered. The present intention is to bring the railway southwestward to Kwei-ling. The further route southward apparently misses the two important centres of Liu-chow and Nan-ning. It is notable that at present the State of Kwang-si depends entirely on its rivers for transport. Wu-chow is at the gate-way, and the trade passes to Canton and Hong Kong. The State is more sparsely populated than most other districts in China. It is rich agriculturally and in minerals. Tin and antimony are mined, and a silver deposit of importance has been developed by Canton residents. The new railway, when constructed, will not only encourage the development of the mineral resources of Kwang-si, but will greatly facilitate communication between the great mining State of Hu-nan and Canton and Hong Kong. The port of Yam-chow, which will be the southern terminal of the railway, is little known at present, and much work will have to be done in order to fit it for future requirements. As this port is also to be the terminal of the railway to connect Yunnan with the sea, to be built by French concessionaires, it will eventually play an important part in the development of Southern China.

Gold Production of the World.

It has been our custom in previous years to devote considerable space in our February issues to reviews of the gold production of the world during each preceding year. This year the difficulties of obtaining reliable information have been unusually great, and the opportunity seems appropriate for confessing that in many cases figures for gold output are founded on guess-work. The table herewith given is far from complete, for in particular all the Canadian figures are not yet available. The outstanding features are the continued fall in the output of Australia, the drop in the United States figures, and the advance in the Transvaal yield. The Canadian figures will probably show an advance, due to increasing prosperity at Porcupine, Ontario. If we had reliable figures we could say also that the outlook in Korea and Russia is good. The yield in the United States showed a substantial fall during 1916, the total being worth £18,955,000 as compared with £20,745,000 during 1916.

PRODUCTION IN BRITISH EMPIRE.

	1915	1916
	£	£
AFRICA:		
Transvaal	38,627,461	39,484,934
Rhodesia	3,823,166	3,895,311
West Africa	1,706,473	1,615,306
AUSTRALASIA:		
West Australia	5,140,200	4,510,000
Victoria	1,397,800	1,090,000
Queensland	1,078,500	940,000
New South Wales	562,000	459,000
South Australia	25,000	20,000
Tasmania	50,000	50,000
New Zealand	850,000	800,000
Total Australasia	9,103,500	7,869,000
INDIA	2,366,457	2,299,568
CANADA:		
British Columbia	1,265,000	1,106,000
Ontario	1,643,000	2,100,000
Yukon	975,000	900,000
Total Canada	3,883,000	4,106,000
FEDERATED MALAY STATES	50,000	50,000
BRITISH BORNEO	270,000	250,000
BRITISH GUIANA	215,000	200,000
EGYPT AND SUDAN	75,000	70,000
Total British Empire	60,120,000	59,840,000

REST OF THE WORLD.

	1915	1916
United States:		
Main Portion	17,043,000	15,302,000
Alaska	3,431,000	3,335,000
Philippines	271,000	318,000
Total United States	20,745,000	18,955,000
Mexico	3,280,000	3,000,000
Central America	770,000	700,000
South America	2,608,000	2,600,000
Russian Empire	6,000,000	6,500,000
Europe other than Russia	595,000	400,000
Japan and Korea	2,215,000	2,500,000
China	755,000	750,000
Madagascar	200,000	170,000
Congo	375,000	350,000
Dutch East Indies	670,000	650,000
Total Rest of World	38,213,000	36,575,000
TOTAL FOR WHOLE WORLD	98,333,000	96,415,000

The decreases were chiefly in Colorado and Nevada. The former State has been declining as a gold producer for some years, though it still occupies second place, California coming first. As regards Nevada, the exhaustion of the rich ore at Goldfield accounts for the drop. As regards the Alaska lode mines, the deficiency in the Treadwell output was balanced by the new Gastineau production. The brightest feature of the table is, however, the steady output in the Transvaal. The increase in the Far East Rand is a full off-set to decreasing yields at some of the old outcrop mines. During the next few years several of the old mines will come to an end by exhaustion of their areas, such as Robinson, Simmer & Jack, and Ferreira Deep, while the future of Nourse, Bantjes, and East Rand Proprietary is doubtful from the point of view of payability, but the Far East Rand will make good the decline. We have not space in this issue for the dissertation on the future of the gold industry of the world which we contemplated writing, so we shall revert to the matter again next month.

Oil Prospects in England.

We have quoted several papers during the past few months dealing with the possible resources of petroleum and oil-shales in England. These papers have been read before the Institution of Petroleum Technologists, a new society that is giving evidence of a robust constitution. The object of the papers has been rather to indicate lines of research for the members of the institution than to assert that the country has untapped mineral wealth. The daily press has, with its usual habit of jumping to hasty conclusions, and of misapplying the principles of inductive logic, given a wrong impression of the purport of these papers, and has made many rash announcements relating to a future petroleum industry for this country. To place matters in their right focus we take this opportunity of examining the exact position. Preliminarily we may remark that we are not concerned now with the Scottish oil-shale industry, which has been established on a business basis for many decades.

We take first the oil-shales known to exist in England. For many centuries oil-shales around Kimmeridge, in Dorset, belonging to the Oolite beds, have been known and have been worked intermittently. Their outcrop can be seen on the cliffs between St. Alban's Head and Portland. Thence the sub-outcrop passes inland in a northwest direction, afterwards veering round to northeast and passing through the Midland counties to Norfolk and East Yorkshire. There is evidence that the shale was used as fuel in pottery manufacture in prehistoric days. In the sixteenth century it was used for evaporating sea-water and the production of salt. In the middle of the nineteenth century a distilling industry was founded at Weymouth, and various oils, together with ammonia fertilizers, were produced. Undoubtedly these beds contain unmeasurable supplies of oil, but unfortunately the sulphur content is high, and no efficient refining method has so far been devised to reduce this constituent to the necessary minimum. Mr. W. Hardy Manfield read a paper on the subject in February a year ago before the institution named, for the purpose of spurring his professional brethren to search for a suitable process of refining.

A less-known occurrence of Oolite shale was described by Mr. W. Forbes-Leslie at a meeting of the same society in October last. This is situated to the south of King's Lynn in Norfolk, and much of the credit for the work of proving it by boring is due to Mr. John Wells. Two types of oil-shale have there been distinguished, both of them lying in the upper horizons of the Kimmeridge clays. The upper series consist of dark brown shale of bituminous appearance, included in dark blue clays and capped by limestone. The lower series are more open in texture, are bluish in colour, and contain marine fossils and fish remains. In the upper series two rich oil-seams have been discovered, one of them 6 ft. thick and yielding on distillation up to 50 gallons of oil to the ton. In the lower series, one of the oil-seams is 7 ft. thick, and yields up to 51 gallons of oil per ton. The oil and its products are similar to those at Kimmeridge, and unfortunately also the sulphur content is high.

We pass now to the occurrences of petroleum as distinct from oil-shales. Here again we have to thank Mr. Forbes-Leslie, for contributing a useful account of the chief recorded occurrences in England. As an outline of his paper is given in the Mining Digest in this issue, we need not enter into details here. Suffice it to say that for a hundred years seepages and flows have been detected in many parts of England, particularly in south Lancashire, Yorkshire, Nottingham, and Derbyshire, with others in Denbigh, Glamorgan, Somerset, and Devonshire, and in the east Yorkshire, Lincolnshire, and west Norfolk regions. These flows are traced both to the lower Carboniferous and to the Oolite. Though the occurrences are so wide-spread, Mr. Forbes-Leslie omits to lay stress on the fact that all of the flows have been unimportant or evanescent. A few have been either of historic importance or may be considered as affording some encouragement for systematic search. Among those of historic interest may be mentioned the flow at a colliery at Alfreton in Derbyshire, where seventy years ago Dr. James Young, afterwards the founder of the Scottish shale industry, collected a few barrels of petroleum per day. The flow was evidently not sufficiently attractive or he would not have transferred his energies elsewhere. Of promising prospects the one most quoted is the bore-hole at Kelham, near Newark in Nottinghamshire. Here a bed of porous sandstone below the Coal Measures was intersected at a depth of 2,450 ft., and the oil contained in it arose of its own accord to the surface. The flow has not been sufficient to attach more than a geological interest to the incident. Mr. Forbes-Leslie, in his paper, proceeds to elaborate his theories to be used in searching for oil. He proposes to investigate the hidden geology of the most likely districts, with the object of locating buried anticlines or other structures associated with oil accumulations, and he gives a mass of collected evidence in this direction. He indicates one anticline that might be explored for Oolite reservoirs, and two or three that might provide oil from Carboniferous strata. The thing to do now is to sink a few holes to test his reasoning. Naturally it may be objected that the depths of these holes would be against the commerical success of such an enterprise, but that remains to be seen.

The foregoing is merely a brief statement of the present position, as we see it. The possibility of finding hidden stores of petroleum seems remote. On the other hand there is no reason why some process should not be discovered whereon to base a practical industry in connection with the Oolite oil-shales.

State Mining on the Rand.

In our November issue we brought forward a suggestion made by Mr. Ernest Williams for State participation in the development of the Far East Rand. This proposal has been received with great interest in many quarters, although most engineers and financiers hesitate to express a definite opinion as to the merits of the suggestion. The most important pronouncement on the subject comes from Mr. R. N. Kotze, who, in his evidence before the Royal Commission, indicated that Mr. Williams's idea had received his serious consideration, though he was not prepared to discuss it on that occasion. At the call for greater detail, Mr. Williams elaborates his scheme in an article appearing on another page in this issue. For the benefit of those who missed the former article, we may say that, briefly stated, the suggestion is that the State should sink twin or triple shafts at some suitable central point and construct the necessary underground station ; that these shafts should serve a wide area of ground, far more extensive than any at present operated by one company ; and that this area should be sub-divided into sections suitable for exploitation by individual companies, these sections being connected with the shafts by main haulage-ways in the foot-wall country. The arguments in favour of such a scheme are manifold. In the first place, this State provision of hoisting accommodation would so greatly relieve the financiers of preliminary capital burden that much better terms could be obtained by the State in the matter of its share in the profits. The cost of reaching any section in this area by drifts is much less than by sinking from the surface. The risk on money spent would be greatly reduced, from the point of view of both the State and the individual, by the operations being spread over a wide area. Further, a very great saving would be effected in the cost of hoisting, and the shaft-efficiency would be notably increased. It is a well known fact that under present conditions on the Rand the amount of ore raised is far below the real capacity of the shafts, with the consequence that the total cost of mining is higher than it should be. Mr. Williams's group of shafts could be designed in relation to the area to be served in such a way that a general speeding-up would be possible.

Since we wrote on the subject in November, the Government and the mining houses have come to a better understanding, and terms have been agreed for the State share of the profits in the Modder East and South Brakpan areas, so the position is not now so much that of a deadlock; but the State advantage of a central scheme still stands, for by its means the total capital expended on the development of the Far East Rand would be less, and the State and individual profits would be higher than by the present system of developing new ground. This recent agreement of the State and financiers is not the basis of the only objection urged to Mr. Williams's proposal. It has been argued that the time occupied in sinking such a group of shafts would involve great delay, and that the cost would be too serious. We do not deny these factors of time and cost. No doubt the early inconvenience should not be overlooked, but it is necessary also to remember the great length of time that the shafts would be in operation. Good work, and work on a large scale, will pay in the long run, for not only would the working cost be decreased, but the cost of repairs and maintenance would be reduced to a minimum. Speed in shaft-sinking is one of the mining engineer's little fetishes, and records for rapid work in this connection are eagerly sought; but many a man has lived to see the day when trouble with his shafts has made him regret the brief triumph of rapid construction. It is usually his successor that suffers the inconvenience. The neck-to-neck competition for records in shaft-sinking introduces many fatuities; for instance, the successive victors seldom say anything of the hardness of the rock, the water encountered, or the quality of the work done.

From the general point of view of the technology of shaft-sinking, Mr. Williams's proposals afford a variety of points for study. In the first place, his shaft is far bigger in cross section than anything hitherto attempted, and secondly, his favouring of the elliptical shape revives the discussion as to the relative advantages of the various types. We believe that elliptical shafts have been employed in this country, and that shapes approximately similar have been recommended in connection with concrete linings in the Lake Superior region, and in some of the United States coal districts. A curvilinear shape has an important bearing on the strength of the walls of the shaft, and on the convenience in excavating the rock. The support required for the walls of a long rectangular shaft is far greater than that for a circular or elliptical shaft, and the margin between the actual excavation and the measurement "within timbers" is much less. The circular shaft has the advantage that the odd corners provide ventilation passages, so requisite in deep mining; but, on the whole, these passages are disproportionately great, and in any case their shape is such that too small a proportion of the area of the shaft is available for the skips or cages. The elliptical shape offers a compromise; a larger proportion of the space is available for hoisting than with a circular shaft, and at the same time there is fair provision for the ventilating current. Another point in connection with Mr. Williams's shafts that requires notice is the fact that they are to be lined with ferro-concrete. The strength and smoothness of surface are not the only advantages to be gained by this design, for it has to be remembered also that a strongly lined shaft will keep back the water in the strata through which the shaft passes. It is well known that the dolomite beds overlying the Witwatersrand Series in the Far East Rand are full of water, and that this water has been a constant source of trouble to several of the mines. The expenses of pumping are high, and the income from the sale of water to the public authorities is far from affording adequate compensation. The multiplication of shafts in the Far East Rand may seriously interfere with the water-supply of Pretoria and other towns, and for this reason, great central shafts, adequately lined so as to control the escape of the water from the dolomite, would be of public benefit.

Before leaving this subject, we desire to draw attention to the fact that these big shafts would afford the opportunity for departing from the rigid system of shifts as at present established. The native labourers have to go to their work and leave it by way of the cages. They have no other means of ingress or egress, and they have to keep definite hours for their upward and downward trips. If they were able to continue their work to more convenient periods for cessation, instead of having to adhere to whistle time, operations would be more continuous and more economical. Mr. Williams's scheme provides a wide stairway round the fan shaft. Some people may think that the daily descent and ascent of a vertical shaft 3,000 ft. deep would be too much for the miner. These journeys would assuredly be unacceptable to the white man, but the native labourer is fleet and resilient and he would probably see no objection. As a compensation he would be given a ride along the haulage-ways. In concluding this outline of the central-shaft proposal, we take the opportunity of inviting engineers to give their views and opinions.

"Russian and Nomad."

When a mining engineer puts pen to paper it is usually with the object of writing a monthly, yearly, or special report for his directors or his clients. Under these circumstances he must, in duty bound, confine himself to hard facts, and choose his words with such precision that no misinterpretation is possible. Even when discussing future prospects, his vocabulary should be restricted. His report is no place for rhetorical flourishes or flights of fancy. Thus it is that the engineer becomes unconsciously hardened and narrowed in his literary ideas, and in many cases the exercise of the belles lettres grows distasteful. Now and again a member of our profession breaks these rigid bounds, and writes a book in which nature and the human character take first place, with technology relegated to the background. Curle has given us "The Shadow Show"; Mackintosh Bell has written of the "Wilds of Maoriland." We now have the pleasure of introducing to the notice of our readers "Russian and Nomad," written by Mr. Edward Nelson Fell. Mr. Fell is known as the pioneer engineer of the modern epoch of British participation in the development of the copper resources of the Russian Empire. He is a New Zealander by birth, an Englishman by education, graduating A.R.S.M. in 1879, and an American by adoption. He had professional experience at the St. John del Rey in Brazil, at iron works in Alabama, and at the Ymir gold mine in British Columbia, before answering the call of his brother, Mr. Arthur Fell, to go to Russia and inaugurate the work of the Spassky company. That company was formed in 1902, but tantalizing delays occurred in obtaining possession of the property, collecting suitable labour, and establishing modern methods of treatment. Steady progress was, however, made, and in 1907 Mr. Fell retired, after five years of arduous and exhausting labour. Since then he has occupied some of his leisure moments in writing stories of Kirghiz and Russian life, founded on incidents in his own experience. These stories have been published from time to time in the *Atlantic Monthly*, and are now issued in book form as "Russian and Nomad."

Mr. Fell gives us many pictures of the nomad life of the Kirghiz, a race that lives as Abraham and Lot did, speaking an Arabic dialect, and owing allegiance to Allah and his prophet Mahomet. They move about from place to place with their cattle, sheep, horses, and camels, their habitations being tents, their food being preponderatingly animal, and their clothing consisting of felt, wool, and leather. As nothing is ever wasted, and as their clothing is not made for the sole purpose of wearing-out rapidly, as are the goods provided by Western clothing stores, it is not surprising that their wealth accumulates. For seven months of the year they are taking shelter from emery blasts of snowstorms, and from winds that for their fury remind us of Wells's story of the man that worked miracles, who commanded the earth to stop revolving but forgot to bid the atmosphere to stop too. For the other five months they are stationed at summer quarters, tending their animals, gathering fodder for the winter, and cultivating small amounts of farinaceous foods for themselves. When they quit one encampment to seek another, they leave no litter behind like the modern excursionists, no waste paper, no broken crocks, no ashes, and no tin cans. They leave everything tidy and neat, as the fairies do when they "fly to dance and sing, at another fairy ring."

The Kirghiz steppes were not a reservoir for labour when Mr. Fell started operations, and recruiting had to be done among the inhabitants of Little Russia and elsewhere. At one time supplies of labour were provided, by Government help, from among the socialists in the towns along the Siberian railway. No doubt the authorities in those towns were shouting "good riddance," but Spassky was the corresponding sufferer. The unfortunate incidents arising from the presence of these malcontents provide the basis for some of Mr. Fell's stories. While writing of these labour conditions, it should be recorded that these were the days of the Russo-Japanese war, and that discontent with the lack of success of Russian arms, and the wide-spread disbelief in the need for the war, had caused a vast amount of industrial and political unrest throughout the Empire.

Mr. Fell treats his subjects with kindliness and humour, though he confesses that humour is not an ingredient of the Russian or Kirghiz mental equipment. He is sympathetic with races whose manners and customs are totally different from those of Western nations, and he shows that they are often better founded on logic and reason than are those to which we are accustomed. He tells amusing stories of the gastronomic capacities of both races. He remarks that the reason they enjoy eating tallow is because it smells as sweet to them as the violet does to us. His account of the feasting to which he had to submit before paying for the mine would be screamingly funny if we did not appreciate the fact that the incident must have been highly incommoding to himself. Imagine three Institution dinners in one day, those dinners before the war, with a more liberal supply of a variety of wines, and fill in the intervals between them with drinks and light refreshments. That was Russian feasting. The Kirghiz meals of honour were of a different type; not much alcoholic beverage, but sour fermented milk ad libitum, and the whole bodies of sheep and horses. Mr. Fell's account of his adventures with various parts of a sheep's head are reminiscent of Francis Osbaldiston's wrestle with the tup's head at Bailie Nicol Jarvie's; while other meals were as revolting to the Western palate as those of which Gordon Pym partook, as recorded by Poe, at the court of the King of the Savages. But Mr. Fell recounts these episodes in good part, considering himself as the weaker vessel.

The feeding incidents are not, however, all connected with what we should call excess, for some of the anecdotes are mirrors of rare economy. For instance, we commend the following quotation to the attention of Lord Devonport, our food controller: "Reaching home, we were glad of the warmth and the hot tea, though I am afraid our consumption of sugar would have shocked the frugal soul of our apothecary. He takes a lump of sugar from his pocket, nibbles off a small morsel, which he holds between his teeth, and sips his tea through it. In this way his palate is slightly tickled from time to time with the taste of sweetness and he is happy. After nibbling off as many fragments as he drinks cups of tea, he returns the lump to his pocket, where it is ready for the next time. The reader, who may be gentle, but is certainly extravagant, will hardly believe how long a pound of sugar will last under such treatment."

But we have said enough about food. The book is not devoted to the subject to the extent that readers might imagine from our references, for Mr. Fell also extracts humour from the innocence of the Kirghiz in the matter of strikes, from the inability of the Russian accountant to do addition sums without his primitive predecessor of the cash register, and from a variety of other topics. A story-book provides an excellent vehicle for imparting impressions of manners and customs, a better vehicle oftentimes than the book of travel or ethnology. For this reason "Russian and Nomad" is recommended to those who desire a knowledge of conditions in Western Siberia; and during the perusal of the book, the fact should not be forgotten that to Mr. Fell is due no small share of the credit for the establishment of modern base-metal enterprises in the Russian Empire.

REVIEW OF MINING

Introductory.—Political events continue to exert a restricting influence on mining opportunities. The increasing submarine menace is causing disquietude, though as yet the food restrictions as advised by the controller have not reflected the ultimate shortness to be expected. To what extent the necessity for subscribing to the War Loan is recognized cannot be gauged until the lists are closed on the 16th of this month. The severance of relations between the United States and Germany is welcomed for its moral effect, but President Wilson's call to other neutrals can hardly be answered by those whose countries are in close proximity to Germany. We do not wish to see Switzerland, Holland, Denmark, Norway, and Sweden overrun and trampled to death. Extended relief to be granted by the British Government as regards income tax on dividends earned in the Dominions has been actively advocated in mining circles. Australian gold mining companies are gratified at their Government's recognition that their increased profits are not due to the war conditions and are therefore not subject to excess profits tax. In the metal markets, the chief feature has been the rise in the price of tin to over £200 per ton. The other metals have been steady.

Transvaal.—When we went to press last month, the figures for the output of gold in the Transvaal for December and for the year 1916 had not been received. The output during December on the Rand was 748,491 oz., and in outside districts 25,971 oz., making a total of 774,462 oz., worth £3,289,705. The yield during 1916 on the Rand was 8,971,359 oz., and in outside districts 324,179 oz., making a total of 9,295,538 oz., worth £39,484,934. This is the biggest yearly aggregate yet recorded, comparing with £38,627,491 in 1915 and £38,757,560 in 1912.

The Commission on State mining for the Far East Rand has almost concluded its labours, and the report is expected within a week or two. The general feeling is that the commissioners will be against State mining. The Government is already considering the advisability of pressing development by offering additional areas, and is expected to ask for tenders for Eastern Geduld, Southern Geduld, Springs (the triangular shaped farm), and the part of Rietfontein not already taken up by Springs Mines Limited. A map of the district is given on page 90 of this issue. Readers should not confuse Springs farm with Springs mines. Elsewhere in this issue we refer to Mr. Ernest Williams's proposals for State participation. It is not too late for the Government to consider the advantages of this scheme.

A new producer has started milling in the Far East Rand, namely Springs Mines. It is over two years since a new mine commenced milling on the Rand, Government Gold Mining Areas starting in October 1914, and Modder Deep in December of the same year. The Springs company was formed in 1909 by the Consolidated Mines Selection Co. The reef was intersected at the two shafts in March and August 1913, respectively. The metallurgical plant has a capacity of 30,000 tons per month. The proved reserve is sufficient to last for five years, and only a small portion of the area has yet been developed.

Several of the companies operating in the Far East Rand have issued statements relating to ore reserves at the end of December. Modder Deep reports 3,320,000 tons averaging 8·4 dwt., as compared with 2,670,000 tons a year ago, of practically the same average. The figures at Brakpan show a maintenance of the total, and a substantial increase in the content, 3,054,000 tons averaging 9·2 dwt., as compared with 3,017,000 tons averaging 7·86 dwt. At Springs Mines, the reserve is estimated at 1,784,000 tons averaging 9·86 dwt.

The Oceana Development Co. announces that a contract has been made for boring on two of their farms in the Heidelberg district. The name of the other party to the contract is not divulged. The map on page 90 of this issue shows one of the farms, Eendracht; the other, Koppieskraal, adjoins on the west. These properties are in ground of debatable value, and for this reason all money involved in the transaction, or in allied transactions, should be devoted solely to the boring operations.

The Simmer & Jack company has purchased 40 claims on the dip from the Simmer Deep. This area is estimated to contain 1,160,000 milling tons in the Main Reef and Main Reef Leader, averaging 4·57 dwt. per ton, together with 500,000 tons averaging 4 dwt. in the South Reef. This ground can be worked easier by the Simmer & Jack than by the Simmer Deep, and the profit is estimated at £226,000, from which £124,000 will be paid as purchase price, half of it now and the remainder in yearly payments. The funds so received by Simmer Deep will be applied to the development of its lower levels. As we recorded in our December issue, the payable reserve at Simmer & Jack has been reduced lately by much of the ore in the upper levels proving poorer than expected. The new ground will add two years to the life of the mine.

The Bantjes position is becoming increasingly serious. The reserve at the end of December was calculated at 198,300 tons in the Main Reef Leader, averaging 5·8 dwt. over 44 in., and 213,700 tons in the South Reef, averaging 5·5 dwt. over 41 in., making a total of 412,000 tons. This is 236,000 tons less than the year before, and the average assay-value is ½ dwt. less. Large blocks of South Reef previously considered payable have had to be omitted in the most recent estimate. It is generally felt that a stoppage of milling is advisable while development is pressed.

For some time it has been known that the May Consolidated property has reached its end. A meeting of shareholders is to be held in April to pass a resolution to appoint a liquidator. The company has a valuable asset in its holding of 28,875 shares in Modder Deep, which, at the present market valuation, are worth £200,000.

Attention is once more attracted to the gold resources of the northern Transvaal by the commencement of mining on the Ophir and Courtney reefs by the newly formed company, Ophir Gold Mines Limited. The moving spirit is Mr. W. T. Hallimond, who until recently was a well known mine manager on the Rand. During a visit to England a year or more ago he interested capital in this venture. The property is 70 miles from Louis Trichart, a station on the Pietersburg-Messina railway. The gold is found in quartz veins traversing ancient schists and gneisses belonging to the Swaziland System. The veins are much crushed at and near the surface, so the ore is easily mined. They average 18 inches in width and the ore as mined assays about 1 oz. per ton. A 5-stamp mill has been erected. It is proposed to raise £40,000 for the purpose of development and equipment.

No gold-mining has been done lately on the New Lisbon-Berlyn properties at Pilgrim's Rest, but attention has been turned towards utilizing the sulphur content of the pyritic ore. A trial shipment of 100 tons has been made to one of the explosive factories in South Africa. Pyrite is scarce in South Africa, and a local source of supply for the manufacture of sulphuric acid is continually sought. One of the company's properties contains large reserves of pyrite averaging 7 dwt. of gold per ton and 0·3% copper. A method of treatment of this deposit on the basis of its sulphur content is contemplated by the board.

Rhodesia.—The output of gold during December was worth £306,203, as compared with £317,135 during November, and £331,376 during December 1915. The total output of gold during the year 1916 was worth £3,895,311 as compared with £3,823,166 during 1915, and £3,530,207 during 1914. The fall for December was due chiefly to a suspension of smelting at the Falcon for 10 days owing to an accident, but a reduction in the output at Cam & Motor, as foreshadowed in our last issue, was also accountable. The Globe & Phœnix continues to increase the average grade of the ore treated, the yield per ton being 139s. 10d. during December, as compared with 127s. 8d. during November, 115s. 6d. during October, and 105s. 9d. during September.

Development in the lower levels at Lonely Reef has revealed some rich ore recently. In the south drift on the 17th level, the ore averages 6 oz. of gold per ton over a width of 29 inches, for the whole of the length, 200 ft. The north drift is 140 ft. long, and the ore averages 2½ oz. over 14 inches. Satisfactory results have been obtained on 15th and 16th levels.

West Africa.—The output of gold in West Africa during December was worth £146,409, as compared with £130,101 during November and £158,323 during December 1915. The total yield for the year was worth £1,615,306, as compared with £1,706,473 in 1915 and £1,727,044 in 1914. The increase during December as compared with preceding months is due to the fact that the yield at Broomassie from the treatment of residues throughout the year is included in the December figures.

Nigeria.—At the meeting of the Nigerian Chamber of Mines, the chairman was able to report a substantial increase in the output of tin concentrate. His estimate for 1916 from returns so far published was 7,250 tons, which compared with 6,500 tons in 1915, 5,011 tons in 1914, and 3,752 tons in 1913. These figures are 15% higher than those we publish in our pages of statistics. Our figures are obtained from the monthly reports of output issued by individual mining companies. The balance is largely represented by the production by tributers and small operators, but it includes also the output of mines worked by the Niger Company.

Australasia.—As mentioned last month, the Broken Hill Proprietary has issued the remaining debentures, £400,000, in order to extend the iron and steel works at Newcastle. These debentures were all subscribed in Australia. Appended to the prospectus is a statement by Mr. G. D. Delprat relating to the position at the works. There were then one blast-furnace with a capacity of 400 tons of pig iron per day; 66 coke ovens in operation and 12 under construction, with a by-product plant recovering tar and sulphate of ammonia; 4 open-hearth steel furnaces in operation, with a capacity of 2,400 tons of steel per week, and another nearing completion; 2 more steel furnaces under construction, which when completed will bring the total capacity to 4,200 tons per week. The blooming-mill and rail-mill have a capacity much greater than the present blast-furnace, and additional mills for rolling bars and wire rods are being erected. It is pressingly necessary to erect a second blast-furnace, not only to cope with increased demand, but to provide against any possible suspension of operations at that now working. It is advisable also to add to the number of steel furnaces, in order to meet the demand and to cheapen the production.

The Broken Hill Block 10 Company has exercised its option on the Massive gold-mining property, on the island of Misima, in the Louisiade Archipelago, 120 miles east of the eastern extremity of Papua. Mr. O. B. Ward, the manager of Block 10, has written a report which shows that the lode has been explored by 5,318 ft. of development work, and that the ore blocked-out amounts to 102,000 tons averaging 39s. per ton. As the faces of the drifts southward are in ore of good quality, and as the lode has every appearance of continuing in depth, the prospects are good for a long ore-shoot containing a large amount of ore. Two other Australian companies also own property on the same line of lode, the St. Aignan's Co., of Sydney, and the Misima Gold Mines Co., of Melbourne, and it has been considered best to amalgamate all the interests. A new company has accordingly been formed with an issued capital of £150,000, of which 69,666 shares of £1 each go to Block 10 in return for £30,000 working capital subscribed and £11,200 cash expended during the option, while 80,334 shares will be distributed among the vendors of the other leases.

Arrangements have been made by the Broken Hill Block 10 Company to treat its slime and zinc tailing by the flotation process, and a plant for this purpose is nearing completion. An arrangement has been made with the Block 14 Company whereby 1,000 tons per week of sulphide ore is to be delivered to the Block 10 plant for lead-dressing and subsequent concentration by flotation.

Further modifications have been made by the Commonwealth Government with regard to excess profits. Mining operations are not to be free from this tax, as stated last month. It is only gold mining that is to be exempt. Copper, lead, and zinc mines are making war profits, and must be taxed. Gold mines, on the other hand, do not do so, owing to the fixed price of the product, and any increase in profits is due to other causes.

The strike at the coal mines in New South Wales has had an unpleasant effect on the output of metals, and the Broken Hill Proprietary has been injured to such an extent as to be unable to pay the customary quarterly dividend. The economic problem of coal supplies has been raised recently in Victoria, where the State mines at Wonthaggi have been shown to be limited and not to fill the State's requirements. Attention is now being turned to the immense deposits of brown coal in the Morwell district of Gippsland, 75 miles east of Melbourne. As we recorded in our issue of December 1914, these deposits are extensive and several hundred feet thick. Though the calorific power is only one-half of that of New South Wales coal, the deposits are obviously of great economic value.

Canada.—The Canadian Mining Corporation has passed resolutions in shareholders' meeting to wind up and distribute the shares in the Canadian company, the Mining Corporation of Canada. It is only three years ago since this company was formed in London. The object of the formation of the English and Canadian companies was to consolidate a number of companies operating at Cobalt, namely, the Townsite, Lake, City, and smaller companies. The advantage of the consolidation was never generally understood. Though an elaborate report was issued last April, the outlook disclosed was not particularly hopeful, especially in view of the big capitalization. At that time it was said that new properties were being sought in the Russian Empire. This plan appears to have been dropped. The dissolution of the Canadian Mining Corporation is no more explicable than its formation.

United States.—The output of copper in the United States during 1916 is estimated at 866,900 long tons, as compared with 635,500 tons during 1915. These figures relate to metal produced from ores mined in the United States. The most notable increase is that of Arizona, the output being 309,490 tons as compared with 198,250 tons in 1915. Montana has increased from 118,770 tons to 157,830 tons. Michigan stands third with 120,400 tons, and Utah fourth with 100,100 tons. The output of zinc during the year was 600,000 tons, as compared with 452,800 tons. The gold output is estimated at $92,315,000, as compared with $101,035,000 in 1915. California heads the list with $22,110,000, followed by Colorado with $19,009,000, and Alaska with $16,242,000. Colorado shows a fall of $3,500,000 as compared with 1915. Nevada shows a drop from $11,883,000 to $8,428,000. Other notable producing states were South Dakotah with $7,512,000, Montana with $4,575,000, Arizona with $4,378,000, and Utah with $3,593,000. The output of silver is reported at 72,883,000 oz., as compared with 74,961,000 oz. in 1915. There were large falls in Idaho and Nevada, which were counterbalanced to some extent by the increased yield of the metal as a by-product in the copper States.

It has been finally decided to apply the cash assets of Stratton's Independence, Limited, amounting to about £65,000, in subscribing to the War Loan. Ever since the remains of the mine were sold to the adjoining Portland, several attempts have been made to place to advantage the capital obtained by this sale. At one time a deal in the Altai was contemplated, and more recently a potash fertilizer business was investigated. So many shareholders, however, dissented, both at meetings of the company, and by actions in the Court of Chancery, that the directors have had no alternative but to withdraw these proposals. The company is to be wound up in due course and the War Loan assets distributed.

In October we dealt with the position at the Alaska Treadwell group of mines, and with the scheme for amalgamating the three companies and developing the orebody in depth. This month we have received another brochure containing a report on the position by Mr. F. W. Bradley, and a long report by the mine geologist, Mr. Livingston Wernecke, on surface subsidence and water conditions. These reports are amplifications of those already published.

Patent litigation in the United States with regard to flotation is apparently not ended by the recent Supreme Court judgment in favour of Minerals Separation as against Mr. J. M. Hyde. The controllers of Miami and the other big copper companies of that group are intending to continue the fight as regards their use of the Callow patent. It is stated that just over 1% of oil is being successfully used in the plant of the Utah Copper Co., and also it is argued that the gentle elevation in the Callow plant is different from the energetic agitation of the Minerals Separation process.

Malay.—The Deebook Dredging company has had bad luck in the sinking of one of its two dredges, almost immediately after it had been overhauled. To float and rebuild the dredge will cost another £6,000. This company is owned in Melbourne, and operates tin-dredging property at Renong, Siam. The ground has been found patchy, and occasionally the tin content falls to an unpayable level. An extensive boring campaign was therefore undertaken, with the object of obtaining a closer assay. By the results obtained it will be possible to reject perhaps one-third of the area. According to the last yearly report, the yield per cubic yard was 0·712 lb., the net cost 5·25d., and the net profit 1·95d. The figures for cost include repairs and renewals, but no allowance is made for depreciation.

Russia.—The Sissert company reports slow though steady progress. The Degtiarsky deposit has been proved sufficiently to make a reserve of 3½ million tons certain. This ore is massive pyrites containing 2·77% copper with gold and silver values averaging 3s. per ton. Mr. N. C. Stines is now engaged in arranging the development and mining programme. Mr. E. J. Carlyle has prepared plans for the new metallurgical plant, at which the ore at the Degtiarsky and also at the Sysselsky, Gumeshevsky, and other older mines will be treated. None of the oxidized ore is being leached at present, as the Government requires all the sulphuric acid for other purposes. The company has two local sources of coal. The deposit recently purchased contains good coking coal, which will be of great value at the new smelter.

Portugal.—The Wolfram Mining & Smelting Co. is a London company working mines at Silvares, Portugal. On the outbreak of war, operations were suspended, as the only market for the output was then closed. Toward the end of 1915, a new contract was made to ship the concentrate to England. The monthly output is now about 29 tons, which is greater than ever before. The report for the year ended September 30 shows that the sales brought an income of £52,458 and a profit of £22,808. The shareholders received £12,800 free of tax, being at the rate of 15%.

Bolivia.—The Aramayo Francke Mines Limited has failed to obtain the sanction of the English Courts to wind up and transfer the assets to a company registered in Switzerland. In the issue of the Magazine for September last, it was recorded that this company, operating tin, wolfram, and bismuth mines in Bolivia, and owned predominantly by Bolivians resident in England and France, had decided to move its head-quarters from London to Geneva and transfer its assets to a new company to be formed there, in order to escape the English income tax. It was stated at the time that the Public Trustee, who was in charge of certain shares in the company held in Germany, had objected at the shareholders' meeting to this move, but that the resolution was carried against him. It appears that subsequently he took steps in the courts to prevent this winding-up and transfer, by applying for a controller of the company under the Defence of the Realm Act. The judges had no difficulty in arriving at a conclusion, and the transfer abroad of the control was prevented. It was obvious that a company producing wolfram and bismuth was better not so near Germany, though everyone knows that Mr. Avelino Aramayo is friendly to the Allies. The only reason for the proposed transfer was to avoid the English income tax. The judges pointed out that the company, though owned by Bolivians, had surely received some benefit from its British domicile, so that the court's attitude must be accepted as reasonable. In all probability the Chancellor of the Exchequer will give some relief in this and similar cases, following the decisions expected with regard to companies operating in the British Dominions.

BUCKET-DREDGING FOR TIN

IN THE

FEDERATED MALAY STATES.

By HARRY D. GRIFFITHS, M.Inst.M.M., M.Inst.C.E.

(Continued from page 33 in the January issue).

Chapter III.—Management—European Staff—Native Labour—Labour Contracts—Size and Capacity of Dredges—Costs of Working—Costs Sheets—Working Details—Working Time—Fuel—The Local Coal Supplies—Water—Sluice-Area—Boilers and Engines—Workshops.

MANAGEMENT.—The management of tin-dredging companies is entirely in the hands of Europeans, who in some cases are under the technical control of some firm of well known mining engineers, and in others are sole masters, and responsible only to their board of directors. In the first case the firm keeps and pays all accounts, compiles all statistics regarding the work, pays out dividends when declared, appoints the mine staff, and altogether acts as general managers. The firm seldom charges a fee for its work, but recoups itself from the dividends received from their holding in the company. Otherwise small commissions on the mine profit and on all purchases of supplies are taken as fees. Both arrangements are economical and efficient, ensure steady and reliable work, and eliminate the possibility of any untoward incidents in actual working.

In the other case, the manager on the spot shoulders the whole responsibility of the work, but is relieved of legal business, payment of dividends, etc., by some firm appointed as attorneys or agents of the company.

EUROPEAN STAFF.—This generally consists of a manager, who in the case of only one dredge being at work may also act in the capacity of engineer and mine accountant, of a dredge master or engineer, and of winchmen. The work being done on 3 shifts of 8 hours, the theoretical number of winchmen is three per dredge, but experience has now proved those to be generally unnecessary, as the Chinese have cleverly adapted themselves to the work, and are giving great satisfaction. Under a careful and tactful dredge master they perform their work exceedingly well.

The best example in the country may be quoted in the case of the Ipoh Tin Dredging Co. Ltd., which is under the technical control of the Borneo Co. Ltd. The whole staff consists of a manager (a well known mechanical engineer) who also acts as engineer, dredge master, mine accountant, etc., and one assistant. Between them they divide the time and the work, and the results achieved are entirely satisfactory.

The manager need not be a mining engineer, but he must possess a good knowledge of mechanical work, management, organization of labour, and local language and conditions, and must possess tact. The following table shows how the European staff of some of the dredging companies is composed:

Company	No. of Dredges	Manager	Engineer	Dredge master	Winchmen	Total
Malayan Tin...	4	1	1	1	4	7
Tronoh Mines	2	1*	1*	1	6	7
Tekka Taiping	1	1	1	1	1	4
Kamunting	1	1	–	1	3	5
Ipoh Tin.........	1	1	–	1	–	2

*General Manager and General Engineer of the company, which does a large amount of other mining work.

Most of the dredge masters and winchmen employed have been specialists in their line in Australia, New Zealand, Siam, etc., and have given great satisfaction.

NATIVE LABOUR.—The native labour mostly employed is Chinese, although Bengalis and Tamils are employed as firemen, engine drivers, greasers, and fuel men. As winchmen, riffle attendants, riffle cleaners-up, etc., the Chinese are preferred to other classes.

The ruling rates of wages are as follows:

	Dollars per day	
Winchmen.........	1·80 to 2·50	Chinese
Assist. winchmen	1·00 to 1·25	,,
Sluice man.........	1·00	,,
Engine drivers....	0·90	Chinese and Bengali
Firemen	0·80	Bengali
Riffle attendants	0·70	Chinese
Greasers............	0·50	Tamil
Surface boys	0·60 to 0·65	Chinese and Tamil
Blacksmith	1·50	Chinese
Striker	0·80	,,
Carpenter	1·00	,,
Fitter	1·45	,,
Boiler maker	1·10	,,

	Dollars per month	
Clerk	70	Chinese
Sample washer, etc.	45	,,
Watchmen	14	Bengali

1 dollar = 2s. 4d.

The following two examples show the total number of hands employed daily (3 shifts):

	Ipoh Tin	Kamunting
On Dredge	53	47*
At Surface (exclusive of mechanics, etc.)	18	12
Mechanics, watchmen, etc.	21	67
	92	

* Plus 32 for 2 hours cleaning-up.

The average labour in connection with dredging companies in 1915, according to Government returns, was about 95 per dredge, the lowest being 60 and the highest 109.

LABOUR CONTRACTS.—In order to take advantage of the natural partiality of the Chinese labour for piece-work, and to ensure a steady supply of the labour needed, monthly contracts are often given to "Kepalas," or head men for different parts of the work. This answers well, and lightens the work of time-keeping, making-up pay-sheets, and paying wages. Thus, small contracts may be given for sluice attendants, cleaners-up, winchmen, firemen, etc.

The dressing of the dredge concentrates to a marketable product is almost entirely given on contract. The price of the work, which comprises concentrating, drying, and bagging, varies greatly according to the number of piculs produced, the quantity of impurities present, and the degree of purity required by the management. A small bonus is also generally added when uniformity of product is maintained. The objects aimed at are high assay-value of all concentrates, and highest proportion of first-class ore. The cost of tin-dressing on contract varies from 25 cents to 60 cents per picul of clean dry concentrates.

SIZE AND CAPACITY OF DREDGES.—The size of the buckets used varies from 6 to 12 cubic ft. Of the first size there are two dredges actually working, and several under order or construction, all belonging to Australian companies, and the buckets are close-connected. In the other cases the buckets are link-connected. The capacity of the dredges varies from 70,000 to 100,000 cubic yards monthly. The tendency, based upon the results of the latest type of dredge, is to have a machine of large size with buckets of 11 to 12 cubic ft., and of a capacity of about 90,000 cubic yards per month. In Table VIII. particulars of the dredges now at work are given.

COSTS OF WORKING.—These naturally vary according to the number and size of the dredges at work, the nature of the ground worked, and the local conditions, but nevertheless the variations are small. Table IX. gives in detail, as far as has been ascertainable, the distribution of the costs for 1915 and the first six months of 1916.

In the majority of cases the greatest expense is that of fuel, which has attained 42% of the total mine costs.. The costs of renewals and repairs of several dredges cannot fairly be compared with one another unless the dredges have been at work for a period exceeding 12 months. The head-office expenses show some variations according to the period of actual working of the dredges. From the table, it would appear that the highest operating costs have been 13½ cents or 3·78d., the lowest 10·72 cents or 3·004d., and that a fair average all round may be taken at 12 cents or 3·36d.

If the working costs are reckoned in values of catties per cubic yard, the results given in Table X. are obtained.

TABLE X.—CATTIE-VALUES PER CUBIC YARD COVERING WORKING COSTS.

Company	Dredge	Catties per cu. yd.	lb. per cu. yd.	Calculated from
Tronoh Mines	No. 1	0·225	0·297	Directors' Report Dec. 30, 1915
,, ,,	No. 2	0·253	0·337	
K. Kamunting	No. 1	0·238	0·317	Directors' Report Feb. 29, 1916
Chenderiang	No. 1	0·164	0·219	Directors' Report March 31, 1916
Ipoh Tin	No. 1	0·210	0·280	6 months to June 30, 1916
Malayan Tin	1-2-3-4	0·208	0·247	Directors' Report June 30, 1916
Kamunting	1	0·221	0·295	Directors' Report June 30, 1916

COST SHEETS.—The methods of keeping the cost sheets vary according to the fancy of the managers, and in some cases they contain a large variety of details. Every item of expenditure is worked out monthly in cents per cubic yard, and this enables the management to keep an effective control of all departments, and to effect economies in different directions. Examples of two methods of keeping cost sheets are given in Tables XI. and XII.

WORKING DETAILS.—Numerous statistics of all the workings are generally kept at the mine, notably those relating to loss of dredging time, spares and renewals, tin and assays, mine profit, etc. The former are only obtain-

Table VIII.—Dimensions and Capacity of Dredges.

	Malayan Tin				Tronoh Mines	Ipoh Tin	Kamunting	Kampong Kamunting	Tekka Taiping	Chenderiang	Trong Tin
	No. 1 Dredge	No. 2	No. 3	No. 4				2 dredges			
Designed by	F. W. Payne & Co.	F. W. Payne & Co.	F. W. Payne & Co.	F. W. Payne & Co.	F. W. Payne & Co.	T. N. Bluck	T. N. Bluck	—	T. N. Bluck	T. N. Bluck	—
Constructed by	A. R. Brown & Co.	A. R. Brown & Co.	A. R. Brown & Co.	A. R. Brown & Co.	A. R. Brown & Co.	Werf Conrad	Fraser & Ch'lm's	C. Ruwatt & Co.	Werf Conrad	W. Simons & Co.	Ruwatt & Co.
Country	Eng'nd	Eng'nd	Eng'nd	Eng'nd	Eng'nd	Holland	Eng'nd	Austr'la	Holland	Eng'nd	Austr'la
Size of Hull:											
Length	150 ft.	150 ft.	162 ft.	166 ft.	166 ft.	139 ft.	139 ft.	130 ft.	134 ft.	127 ft.	120 ft.
Breadth	34 ft.	40 ft.	40 ft.	42 ft.	42 ft.	42 ft.	42 ft.	44 ft.	40 ft.	42 ft.	40 ft.
Depth	7ft. 4in.	7ft. 10in.	7ft. 10in.	7ft. 10in	8 ft.	8 ft.	8 ft.	8 ft. 4 in.	8 ft.	8 ft.	8 ft.
Capacity of Buckets in cu. ft.	10	11	11	11	12	7	7½	6	12	10	6
Speed of Buckets p.m.	10–12	10–12	10–12	10–12	12	12–14	12	20	11	16	16
Digging Depth	50 ft.	50 ft.	60 ft.	60 ft.	60 ft.	49 ft.	45 ft.	45 ft.	45 ft.	40 ft.	30 ft.
Capacity of Dredge per hour	106	121	153	153	167	102	170	153	220	112	210
" " " per month*	57,350	68,590	87,016	92,866	85,716	66,200	99,000	67,370	74,000	88,150	—
Horse power employed	250	300	300	300	315	237	200	200	220	180	200
Area of Sluices sq. ft.	4,044	5,220	5,220	6,032	6,144	3,040	3,100	3,500	2,800	2,802	1,636
No. of Sluice decks	2	2	2	2	2	1	1	1	1	1	1

* Average from particulars furnished by the companies

Table IX.—Working Costs of Bucket-Dredges in 1915 and 1916 (6 Months)
In Cents per Cubic Yard.

Compiled from particulars furnished by the Companies or from published Reports.

	Malayan Tin				Ipoh Tin		Kampong Kamunting		Kamunting		Chenderiang		Tekka Taiping		Tronoh Mines	
	1915		6 mos. 1916		1915 4 mos.		1915 6 mos.		1916 6 mos		1916		1915		1916 6 mos.	
	Cents	%	Cents	%	Cents	%	Cents	%	Cents	%	Cents	%	Cents	%	Cents	%
	(a)		(b)		(c)		(d)		(e)		(f)		(g)		(h)	
Mine Costs:																
Management, Eng. Salaries	2·35	19·49	1·82	16·23	2·21	20·04	1·86	15·77	1·73	16·13			4·86	36·00	3·98	33·16
Native Labour	2·94	24·17	2·75	24·53	1·96	17·76	3·02	25·61	1·69	15·76						
Fuel	*4·16	34·21	3·70	33·01	*4·63	41·91	2·18	18·49	2·64	24·63			2·43	18·00	3·28	27·08
Stores	0·32	2·63	0·22	1·96	0·58	4·62	0·44	3·72	0·10	9·93						
Repairs & upkeep	1·75	14·39	2·17	19·35	0·22	2·01	2·71	22·98	1·93	18·00						
Transport	0·21	1·73	0·08	0·71	0·27	2·45	—	—								
Prospecting, Purchase of Ground etc.	0·18	1·48	0·10	0·99	0·45	4·03	0·64	5·43	2·63	24·63			6·21	46·00	4·77	40·24
Ore-Dressing	0·23	1·90	0·37	3·31	0·78	7·07	0·94	8·00								
Total Mine Costs	12·16		11·21		11·03		11·79		10·72		12·50		13·50		12·00	
Head Office Expenses		% of Mine Costs		% of Mine Costs		% of Mine Costs		% of Mine Costs				% of Mine Costs				
Directors' Fees	0·21	—	0·13		0·93	—	0·76	—	—		—	—				
Commissions	0·07		0·63		—	—	—	—	—		—	—				
Secretary & Offices	0·11	—	0·06		0·53	—	0·23	—	—		—	—				
Cables, Legal and Sundries	0·46	—	0·27		1·62	—	0·32	—	—		—	—				
Total	0·85	7·00	1·10	10·00	3·08	27·90	1·31	11·11	1·08	10·00	1·20	10·00				
Depreciation, Etc	—				—		5·00		3·68		2·91					
Total of All Costs ... Cents	13·01		12·31		14·11		18·10		15·48		16·61					
... Pence	3·66		3·44		4·05		5·06		43·3		4·65					

(a) Directors' Report 12 months to June 30, 1915.
(b) " " " " 1916.
(c) " " " December 31, 1915.
(d) " " 6 months to February 29, 1916
(e) Particulars obtained at Mine and from Report June 30, 1916 (4 months work).
(f) Directors' Report 12 months ended March 31, 1916.
(g) " " " " October 31, 1915.
(h) Particulars obtained at Mine.
* Rawang coal used.

TABLE XI.—SPECIMEN COST-SHEET FOR ONE MONTH'S WORK BY ONE DREDGE.

EXPENDITURE	DREDGING			MAINTENANCE			ORE DRESSING			TOTALS				
	Dollars	Cents	Cents per Cubic yard	Dollars	Cents	Cents per Cubic yard	Dollars	Cents	Cents per Cubic yard	Dollars	Cents	Cents per Cubic yard	£ s. d.	Pence per Cubic yard
Wages—European	857	84	0·78	300	00	0·27	125	00	0·11	1,282	84	1·17		
Native	2,239	69	2·03	311	93	0·29	499	75	0·46	3,051	37	2·77		
Fuel	2,111	55	1·02							2,111	55	1·92		
Stores	263	58	0·24	613	96	0·56	47	95	0·04	925	49	0·84		
Renewals				672	24	0·61				672	24	0·61		
Sundry Expenditure ...										222	65	0·20		
Totals.........	5,472	66	4·97	1,898	13	1·73	672	70	·61	8,266	14	7·51	964 7 8	2·10

Hours run	Cubic yards treated	Cu. yd. treated per hour	TIN OXIDE RECOVERED			VALUE RECEIVED				
			Piculs	Tons	Per Cubic Yard in Lb.	Dollars	Cents	Per Cubic Yard in Cents	£ s. d.	Per Cubic Yards in Pence
604	110,000	182·1	749·78	44·63	0·91	42,086	19	38·26	4,910 1 2	10·71

TABLE XII.—SPECIMEN COST-SHEET FOR THREE MONTHS FOR ONE DREDGE.

	October 1915 Yardage 69,500		November 1915 Yardage 65,600		December 1915 Yardage 63,200	
	Amount $	Cents per cub. yard	Amount $	Cents per cub. yard	Amount $	Cents per cub. yard
MINE OFFICE EXPENSES						
Clerks and Office Expenses	112·85	0·16	104·92	0·16	109·22	0·17
General Charges	84·01	0·12	127·10	0·19	81·59	0·13
Freight and Travel Expenses	77·07	0·11	59·68	0·09	77·94	0·12
Bank Charges	13·10	0·02	8·05	0·01	6·55	0·01
Singapore Office Expenses	18·75	0·03	198·93	0·30	344·45	0·55
		0·44		0·75		0·98
DREDGE						
European Salaries	989·27	1·42	964·27	1·47	1,001·26	1·58
Dredge Crew	545·78	0·79	582·37	0·89	594·10	0·94
Sluice-boy Coolies	653·13	0·94	701·65	1·07	787·60	1·25
Transport Ore and Coal	170·00	0·25	160·50	0·24	203·20	0·32
Dams and Waterways	116·90	0·17	135·70	0·21	122·35	0·19
Fuel and Oil	3,001·94	4·32	3,279·50	5·00	2,894·79	4·58
Survey	62·00	0·09	131·00	0·20	31·00	0·05
Materials and Stores	224·19	0·32	400·07	0·61	388·06	0·61
Repairs and Renewals	100·39	0·14	163·30	0·25	167·45	0·26
Ore Dressing and Bagging	598·06	0·86	502·30	0·77	461·95	0·73
GENERAL						
Legal Charges	83·80	0·12	—	—	54·50	0·09
Prospecting	—	—	—	—	130·92	0·21
TOTAL	6,850·76	9·86 Equal to 2·761d.	7,519·34	11.46 Equal to 3·208d.	7,457·33	11·79 Equal to 3·301d.

able with difficulty, and as they are liable to great fluctuations, their publication could not be of any particular interest. A simple working details sheet is given in Table XIII.

WORKING TIME.—The proportion of actual working hours of the dredges, taken over an average of several months, and from the latest information available, is as given in the next column.

		%	Best %
1	Malayan Tin..................	75·60	77·15
2	Tronoh Mines	68·50	—
3	Ipoh Tin	84·45	93·68
4	Chenderiang..................	77·30	—
5	Kamunting	—	—
6	Kampong Kamunting	81·40	—
7	Tekka Taiping	61·11	—

In the case of (4) and (5), the dredges are stopped while the cleaning-up of the sluices is done.

Under this heading there appears to be room for much improvement. The main stoppages have been due to breakages of different parts, replacing of weak or worn-out screens, rollers, link-bushes, etc., and they tend to diminish rapidly as stronger working parts are put in, and better installations for repairs on shore are established. It is probable that at

TABLE XIII.—WORKING DETAILS.

	September	October	November	December	Total
Hours worked	575	619	641	597	2,432
" " %	80 00	83·20	89·03	80·24	83·07
Yardage	50,500	69,500	65,600	63,200	248,800
" per hour	88	112	102	106	102
Recovery Piculs	302·75	426·04	400·01	409·82	1,515·58
Assay of Concentrates %	75·12	75·43	74·62	74·21	75·03
Ore per cubic yard, catties	0·60	0·61	0·61	0·65	0·62
Costs total $	6,938·42	6,850·76	7,519·34	7,457·33	24,855·00
" per cu. yd. $	0·137	0·099	0·115	0·118	0·116
Proceeds total $	13,957·65	21,670·82	20,796·11	21,544·07	76,918·35
" per cu. yd. $	0·276	0·312	0·317	0·341	0·313
" per picul $	46·10	50·87	51·99	52·59	50·68
Price of Tin	73·77	81·07	83·25	84·875	81·10
Profit total $	7,019·33	14,820·06	13,276·77	14·096·74	46,362·25
" per cu. yd. $	0·139	0·213	0·202	0·223	0·197
" per picul $	23·18	34·79	33·19	34·49	31·59
Tribute $	101·47	101·98	18 53	504·02	999·63
Gross Profit $	7,120·70	14,922·04	13,295·30	14,600·76	47,140·85

the present time a considerable improvement has been achieved, and that the average working time of all the dredges is between 75 and 80 per cent.

FUEL.—The fuel used is either firewood or local coal from Rawang. The former varies in price according to the locality, and is apparently still fairly plentiful. It is mostly drawn from Government plantations of mangrove at different parts near the sea-coast and is conveyed by train. The price per ton of 50 cubic feet delivered at the mines is as follows:

	$
Tronoh Mines	4·50
Chenderiang T.D.	4·80
Tekka Taiping	4·25
Kamunting T.D.	4·65
Kampong Kamunting	4·65

The price of firewood has a constant tendency to rise, and it is doubtful whether when the number of dredges has increased considerably the country will supply a sufficient quantity and the railways will be capable of conveying it. There is always the possibility of the Government allowing the cutting of firewood from the numerous and extensive forest reserves, but it is certain that a decrease in the cost of firewood will not take place.

The Rawang colliery in Selangor furnishes a class of coal which seems to answer the requirements of the dredging industry, and which burns brightly, giving very little ash and practically no clinkers. It is inferior in calorific value to any of the imported coals, but in boilers designed with a large grate area for firewood consumption, it answers very well, and gives no trouble in stoking.

It is difficult to establish comparisons between Rawang coal and imported coal or firewood, as no really serious experiments in that direction have been undertaken. The Ipoh Tin Dredging Co. made some comparative tests showing that 10 tons of Rawang were equivalent to $7\frac{1}{2}$ tons of Deshergur coal, imported from India, and the costs at the mine were $89·50 against $112·50. In actual work, the results in Table XIV. were obtained.

TABLE XIV.—COMPARATIVE TESTS OF COAL AT IPOH TIN.

	November 1915	April 1916
Hours worked	641	648
Coal used	Deshergur	Rawang
Weight consumed	228 tons	335
Cost per ton	$15*	$8·95
Total cost	$3420	$2998
H.P. used	237	253
Proportion of coal used	6·80 tons	10 tons
Proportion of cost	$1·14	$1.00
Proportion of coal for equivalent H.P.	7·40 tons	10 tons
Proportion of cost for equivalent H.P.	$1·24	$1·00

*Owing to increased freight, etc., this coal cost in June 1916 $26 per ton.

TABLE XV.—COMPARISONS OF WOOD AND COAL AS FUEL.

	Malayan	Chenderiang	Tekka Taiping	Kamunting	Kampong Kamunting	Tronoh Mines
Fuel used	Rawang Coal	Wood	Wood	Wood	Wood	Wood
Cost per ton	$7·00	$4·80	$4·25	$4·65	$4·65	$4·50
Average H.P. used	287	180	220	200	200	315
Average capacity	77,425	88,150	74,000	99,000	67,370	85,716
Average fuel bill per dredge	$2,275	$2,160	$2,100	$2,353	$2,019	$2,600

The only comparison with firewood possible is with the average monthly fuel bills of each dredge. This may not be a fair comparison, as conditions of power, quantity of work done, proximity to railway or colliery, etc., are not equal. In comparing the case of the Malayan Tin Dredging Co. working with 4 dredges and using Rawang coal, with other dredges using firewood, the results in Table XV. are obtained.

Rawang coal is supplied under contract to the Malayan Tin Dredging Company, but the Ipoh Tin has so far bought at current rates, which are necessarily somewhat higher and fluctuating. The colliery is prepared to contract for supply within certain limits only. It is equipped for a daily output of at least 1,000 tons, but is now experiencing some difficulty in securing the necessary underground labour. It is reckoned that, when in full swing, the cost of getting and delivering at pithead should be in the vicinity of $1 per ton. The royalty payable to the Government being $1, it is reckoned that, allowing the colliery a very fair profit, coal could be delivered under contract at any mine in the Kinta valley at a much lower price than prevails at the present time. The extra railage to the Taiping valley, provided the railway continues fair sliding scales of rates for long distances in favour of the mines, should enable the mines in that district to obtain their coal at very nearly the same price as those in Kinta.

A colliery output of only 400 tons per day should supply all the railways and mining concerns in the country at the present time, but in the near future that quantity will prove insufficient. The railways are quite capable of dealing with the coal traffic now, and will not neglect to make due provision for its future extension. It is hoped, therefore, that the directors of Malayan Collieries Ltd. will soon overcome their labour troubles, and that, satisfying themselves with a fair profit per ton, will be able to deliver their goods at lower rates than now prevail, and thereby largely increase their output. If coal could be delivered at the mines at about $5 per ton, the dredging companies would soon give it the preference to firewood, and a steady and permanent business would accrue to the colliery. With the return of normal conditions, the Rawang collieries should be in a position to reduce the cost of their coal, and every reduction of one dollar per ton, for companies treating 3 million yards annually, like the Malayan Tin, would mean a saving to them of some $15,000 per annum. It is evident therefore that local coal could be of great assistance to the tin-dredging industry, and prove an impetus to its further development, if supplied at a reasonable figure.

The discovery of a new coalfield in Perak, at Enggor on the Perak river, has recently been reported. It is known that the Government geologist has investigated the occurrence, but his report has not yet been published. Should this new deposit prove of commercial value, it would much improve the prospects of tin-dredging in Perak, as it lies midway between the two most important dredging districts, and at a short distance therefrom. The question of fuel is one of paramount importance to the industry and one in which the Government should take a very active interest and control. The importation from the Indian coal districts of the labour required for the coal-mines should be practically encouraged by the Government authorities, who might offer as an inducement for the eventual settlement of the labourers small plots of free ground for those who have worked regularly for a certain number of years. There is plenty of such ground available which would only benefit by occupation, and a permanent settled community of coal-miners would soon be created. There is some reason to believe that the suggestion is not escaping the attention of the Government. I believe that this suggestion first appeared in the *Tin & Rubber Journal* (Ipoh) of June 21, 1916, in an interview with myself.

WATER.—The amount of water required for the efficient concentration of the ground worked by the bucket dredges varies according to its sandy or clayey nature. It should be carefully adjusted to the local conditions, as an excess would be just as detrimental as a shortage. In this respect, several of the dredges at work show a failing in the direction of a shortage, resulting in thick pulp, sluggish flow, uneven deposition in the sluices, scouring channels, and loss of tin which should have been recovered. The supply of water for sluicing on any particular dredge is kept a constant quantity quite independently of the yardage being brought up from time to time, and the result is that the best conditions for efficient concentration are not obtained. Its regulation to secure a pulp of even consistency calls for the earnest attention of those in charge. The result of present practice tends to show that for ordinary clayey sand of the Kinta valley not less than 3,000 gallons of water is required per cubic yard. In the case of the two most recent and successful English dredges some 4,500 gallons is provided for. It is interesting to note that the New Zealand practice in gold dredging is about 17,000 gallons per cubic yard.

The water supply should be made flexible within reasonable limits to suit the constantly changing conditions of the ground. As the supply pumps are generally worked by special engines, the solving of this problem should not offer great practical difficulties. The supply water is drawn directly from the paddock in a more or less muddy condition, which, within certain limits, decidedly assists the concentration. For cleaning up the sluices, the water should be as clear as it is possible to obtain without requiring a special supply.

The water used for feeding the boilers is not drawn from the paddock but secured from some clear source and conveyed to the tanks on the dredge by the most convenient method. The quantity required is small, as all the dredges are provided with a condensing plant.

SLUICE-AREA.—In the case of the earlier dredges the area of the sluices or concentrating tables is admitted to be too small. In some instances, where the buoyancy of the dredge permitted it, additional sluices were placed above the main deck under the main sluices. This has, however, not been possible in all cases, and either the digging speed has had to be reduced, or else the overcharging of the tables has been allowed to continue to the detriment of efficient concentration. The question of sluice-area is extremely important, and should be particularly considered in each individual design. It is better to err on the side of excess area than in the other direction. In the case of the most modern English dredges an area of about 37½ square feet per cubic-yard-hour is provided for, and the results obtained are apparently very satisfactory. The Australian dredges, working mostly in loose sandy ground, have an area of 23 sq. ft. per yard-hour, but it is evident that it could be increased with advantage. The sluices are generally flush, with an inclination when loaded of about ¾ in. per foot, and with occasional slats dropped across into groves. They are invariably lined on bottom and sides with close-fitting planks, with a smooth surface, which assists the concentration and facilitates the cleaning up. There are four sluices on each side of the dredge, of a width of 4 to 5 ft. each. They discharge at a height above water of 9 to 10 ft., and they overhang as far as possible beyond the end of the pontoon, so as to prevent the fouling of its stern. When increasing the area, it is advisable to do so by lengthening the sluices rather than by giving them a greater width. This is generally accomplished by putting in a new set of sluices below the main ones, when the buoyancy allows it. The inclination of the sluices is kept constant by trimming the dredge by means of water ballast. In the newest dredges, a large margin of buoyancy is allowed, and the weights are so well distributed that no water counterbalance is needed, and the dredge when at work keeps perfectly trim.

In addition to the water supplied to the screen through the sparge pipe, some is supplied at the head of the riffles and regulated by hand to ensure proper consistency of the pulps.

BOILERS AND ENGINES.—The boilers are generally two in number, placed sideways on one side of the dredge or facing one another, according to their design. They are mostly of the "dredge" tubular type, but the Malayan Tin and the Tronoh in their latest design have adopted the "dry back" type of marine boiler which answers the purpose exceedingly well. The length is practically equal to the diameter, the combustion chamber is brick lined, and the whole rests on a couple of cast iron cradles. The diameter over all is limited to 8 ft. 6 in. if it is shipped whole, as the local railways cannot take anything beyond that. When a greater diameter is necessary, the boiler is shipped in halves and the two parts are riveted together on the spot. One such boiler only is needed, and economy in weight and in deck space is considerable.

The Australian practice has so far been to use under-fired tubular boilers enclosed in brick lining kept together by an outside steel shell. The weight of those boilers is very great, and their width takes the whole side of the dredge, an overhanging gangway having to be provided. They are not so easily managed or supervised as the other kinds employed, and they are undoubtedly also more expensive.

The "dry back" type has now been thoroughly tested by time (the first Malayan Tin dredge having been equipped with one) and the results have been so eminently satisfactory that it is likely to become the standard type.

As the water for feed purposes is seldom perfectly pure, a feed-water settler is always provided. So far, the boilers have given remarkably little trouble considering the not altogether favourable conditions under which they work, and the greatest loss of time due to boiler trouble has been in the case of the Australian type described above.

The engines on a dredge consist of one main engine to drive the bucket-line and the screen, one engine to drive the pumps, directly connected or belt driven, and separate auxiliary engines for winches, ladder winch, air pump, and electric light. They are of various designs, horizontal or vertical, low speed or high speed, but the most favoured type now recommended is the vertical marine type of moderate speed, and of simple design. These occupy less deck space than the horizontal type, give much less trouble, and cost less in lubricants than the high-speed vertical, and all the parts are more accessible and more easily repaired.

The driving of the bucket-line gearing is invariably by means of belting moving at a speed of 1,800 to 2,000 ft. per minute, and as the ratio of engine speed to that of the top tumbler is from 4 : 1 to 6 : 1, no trouble is experienced as long as the main belt is well protected from the rains or drippings, and that the diameter of the driving pulley is not too small. Some driving belts, after eighteen months of steady work, are in good condition and are likely to last for some months more. The actual horse-power used varies according to the capacity of the dredge and the nature and depth of the ground dug. No important tests to ascertain this have been made, but the horse-power given in Table VIII. is as near an approximation as can be made, and has been accepted as such by the Authorities as tallying with their Rules under the Machinery Enactment. This enactment provides most excellent supervision of all boilers and machinery under competent experts.

Table XVI.—Conversion of Federated Malay States Currency.

Cents	Pence	Cents	Pence	Pence	Cents
				1	3·57
1	0·28	26	7·28	2	7·14
2	0·56	27	7·56	3	10·71
3	0·84	28	7·84	4	14·28
4	1·12	29	8·12	5	17·85
5	1·40	30	8·40	6	21·42
6	1·68	31	8·68	7	24·99
7	1·96	32	8·96	8	28·56
8	2·24	33	9·24	9	32·13
9	2·52	34	9·52	10	35·71
10	2·80	35	9·80	11	39·28
11	3·08	36	10·08	12	42·84
12	3·36	37	10·36	13	46·41
13	3·64	38	10·64	14	49·99
14	3·92	39	10·92	15	53·56
15	4·20	40	11·20	16	57·13
16	4·48	41	11·48	17	60·70
17	4·76	42	11·76	18	64·26
18	5·04	43	12·04	19	67·83
19	5·32	44	12·32	20	71·42
20	5·60	45	12·60	21	74·99
21	5·88	46	12·88	22	78·56
22	6·16	47	13·16	23	82·13
23	6·44	48	13·44	24	85·68
24	6·72	49	13·72	25	89·25
25	7·00	50	14·00	26	92·82
				27	96·39
				28	100·00

\$1 = 2s. 4d. £1 = \$8·5417. \$60 = £7.

To convert large sums from Dollars to Sterling, divide by 60 and multiply by 7.

$$\text{Example: } \$6{,}360 = \frac{6{,}360 \times 7}{60} = £742.$$

To convert Sterling into Dollars, multiply by 60 and divide by 7.

$$\text{Example: } £3{,}720 = \frac{3{,}720 \times 60}{7} = \$31{,}885·71$$

Workshops.—Most of the dredging companies have, of necessity, erected some kind of a workshop where most of the repairs can be undertaken without calling upon the large engineering firms, often situated at great distances, and have consequently effected a saving in time and expenses. Those companies having or contemplating having more than one dredge have erected or are erecting very complete workshops, including a small foundry, which will enable them to undertake all conceivable repairs, with the exception of making steel or other complex metal castings. The cost will be amply repaid by the saving in repairs and maintenance account, and gain in percentage of working hours.

Fortunately the native skilled hands required for a workshop are easily obtainable and, as a rule, efficient and smart mechanical engineers with organizing powers have not been lacking so far. It is reckoned that the cost of a workshop necessary for a plant of 2 to 4 dredges, including buildings, erection, etc., would be between £4,000 and £5,000.

Weights and Money.—For the benefit of readers unaccustomed to catties, piculs, and Federated Malay States dollars, two conversion tables are given herewith, Tables XVI. and XVII.

(To be continued).

Table XVII.—Conversion of Federated Malay States Weights.

1 Cattie = 1·33 lb., 1 Picul = 100 Catties = 133·33 lb.

16·8 Piculs = 1 Ton of 2,240 lb.

Piculs to Tons						Tons to Piculs			
Piculs	Tons	Piculs	Tons	Piculs	Tons	Tons	Piculs	Tons	Piculs
1	0·059	100	5·95	2,000	119·04	1	16·8	20	336
2	0·119	200	11·90	2,100	124·99	2	33·6	30	504
3	0·178	300	17·85	2,200	130·94	3	50·4	40	672
4	0·238	400	23·80	2,300	136·89	4	67·2	50	840
5	0·297	500	29·76	2,400	142·84	5	84·0	60	1,008
6	0·357	600	35·71	2,500	148·80	6	100·8	70	1,176
7	0·416	700	41·66	2,600	154·75	7	117·6	80	1,344
8	0·476	800	47·61	2,700	160·70	8	134·4	90	1,512
9	0·535	900	53·57	2,800	166·65	9	151·2	100	1,680
10	0·595	1,000	59·52	2,900	172·61	10	168·0		
20	1·190	1,100	65·47	3,000	178·56				
30	1·785	1,200	71·42	3,100	184·51				
40	2·380	1,300	77·37	3,200	190·46				
50	2·976	1,400	83·32	3,300	196·41				
60	3·571	1,500	89·38	3,400	202·36				
70	4·166	1,600	95·23	3,500	208·32				
80	4·761	1,700	101·18	3,600	214·27				
90	5·357	1,800	107·13	3,700	220·22				
100	5·952	1,900	113·09	3,800	226·17				
				3,900	232·13				
				4,000	238·09				

In order to roughly convert piculs into tons, multiply by and divide by 100, thus:

$$500 \text{ piculs} = \frac{500 \times 6}{100} = 30 \text{ tons.}$$

THE DEVELOPMENT OF THE FAR EAST RAND

By ERNEST WILLIAMS, M.Inst.M.M., Assoc.M.Inst.C.E.

In the November issue Mr. Williams advocated a plan for developing the Far East Rand, the feature being the sinking of a group of great central shafts, with State control and participation. He now gives details of his proposals.

As I mentioned in your November issue the general conditions obtaining in the Far East Rand favour the exploitation of large areas from a centrally placed group of shafts. The dip of the auriferous deposits is slight and therefore the question of underground transport is simple. Although the dolomite beds to be passed through in sinking to the gold-bearing beds generally yield much water, this can be effectually shut-off by adopting ordinary methods of lining, ordinary that is in the light of present experience. Under the circumstances, the dolomite should be pierced as seldom as possible in case the removal of the water should affect the water-supply of towns drawing their service from this source.

The suggested shafts would be lined with reinforced concrete throughout. The section to a safe distance below the dolomite would be designed to hold back the water, provision being made at each shaft to permit the water to be drawn off, under control, for pumping to the surface as necessity may demand. In order to provide for this, it would be necessary to connect the shafts by drives, at a short distance below the limestone, and establish a pumping station preferably near to the ventilation shaft.

A group of three shafts is suggested, each to be about 52 ft. by 34 ft., elliptical in section, and vertical. The equipment is to be designed for an ultimate capacity of 25,000 to 30,000 tons of ore per day. No 1, the skip shaft, would have 6 double skip-ways; No 2, the cage shaft, would have 3 double cage-ways; No 3, the fan shaft, would have a spiral travelling-way, etc.

The skip shaft may be arranged on the lines indicated in the sketch in Fig. 1. The central circular compartment would be a steel tube serving the double purpose of a free air-way and the framework for supporting the skip guides. The loading and discharging of the skips would be effected at three stages, or levels, so as to avoid crowding the work at any point either above or below ground. Mine cars would dump into the ore-pockets, the ore passing on to the conveyors and into the loaders. The latter would be filled during the journey of the skip and be ready to load the skip immediately it returned to its loading position. This lay-out would make for rapid hoisting. The necessary stations would call for unusually small chambers in the vicinity of the shaft. By placing the centres of the skips radially there would not be the least crowding of winders, of the banking-out, or of the underground loading arrangements.

The bottom of the cage shaft would be laid out in three stages corresponding to the work at the skip shaft. The cages would be long enough to take trucks carrying the longest drill-steels, etc., in general use in the mine direct from the shops or stores to the distributing points underground; and they would carry a good complement of men each trip. The normal duty of this shaft would be to deal with the usual services of the mines. Each pair of cages would serve two sections, as indicated in Fig. 2, of the workings feeding the skip shaft. In case of need this shaft could be used for hoisting mine cars direct.

The fan shaft would have two compartments so that two exhaust fans may be employed to control the ventilation system. Suitable return air-ways as well as travelling-ways would be made between this shaft and the main roads leading to and from the several working districts. These ways are not shown on the sketch, but their distribution would follow the lines usually adopted in the lay-out of large collieries. A spiral travelling-way would be a feature of this shaft. It would be about 7 ft. wide, would have alternating sections of steps and "ramps," and would provide an easy means of ingress and egress between mine and "day." Native workers could use it at times when it would be impossible for them to use the cages, thus making for considerable latitude in the matter of arranging the underground work. A further advantage is the provision of a safe means of egress in case of failure of the hoisting plant. This shaft would carry the lines of the electrical, air, water, steam, and other services incidental to mining operations.

Reinforced concrete work would be adopted in all the shaft-head structures. Cage shaft banking-out would be done at three stages, not necessarily at the same horizons as at the skip shaft, but at levels to suit workshops and stores.

The shafts here advocated are of far greater dimensions than anything hitherto employed and their shape is one to which we are not need be excavated. Where shaft walls are not lined the rock stands much better when the walls are curved. Hoisting cages and skips have less air resistance owing to the all-round clearance, thus allowing more freedom in the ventilating current. Curved unlined walls usually present less irregularities to interfere with the air currents. Shafts of curved section are more readily inspected, and they are more easy to sink, being cornerless.

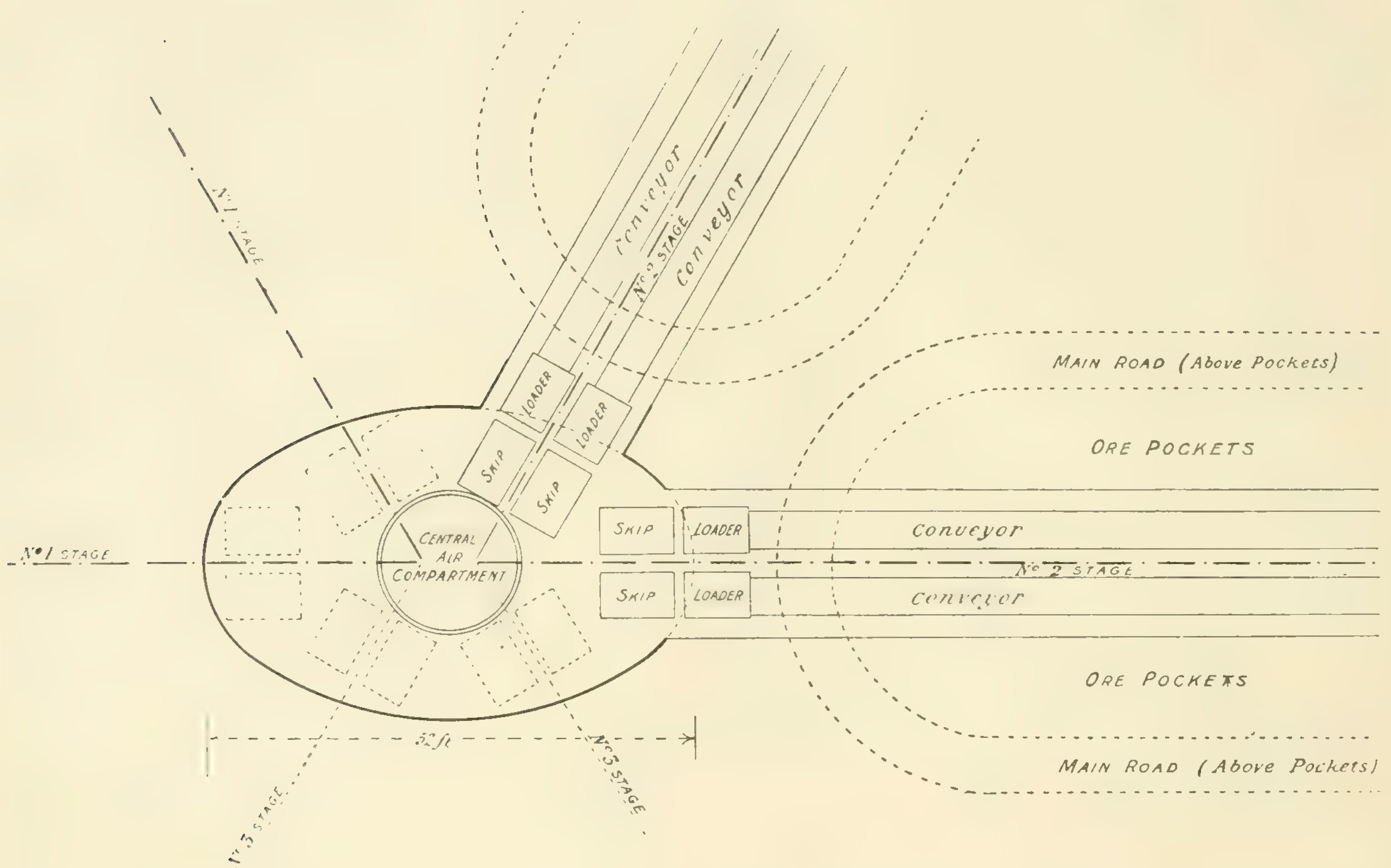


FIG. 1. SUGGESTED ARRANGEMENT OF SKIP SHAFT, CAPACITY 25,000 TO 30,000 TONS PER DAY.

accustomed. It is therefore desirable to enter into details on this point. In the first place, we must remember that the probable life of a mine is the chief factor in determining the shape and the method of lining the shaft. The life of such shafts as I advocate would be long, and the discussion on the subject is accordingly brought within narrow compass.

Circular or elliptical shafts present certain advantages over those of rectangular form. The periphery of the curvilinear shaft requires from one-third to one-half the support necessary for the sides of the rectangular form of shaft, assuming that the same divider support is supplied, and therefore less ground

In the light of present experience, cement concrete possesses the following advantages for shaft lining. It is almost indestructible, is fireproof, is easiest to put in place, requires a minimum of skilled hands, by far the larger portion of its components may in most cases be obtained locally at low cost, its grade can be varied to suit varying conditions, reinforcement may consist of any of a wide range of forms of iron such as plain rods and bars, corrugated, serrated, crimped bars, expanded metal, wire screenings, old wire ropes, rails, etc. It can be put in under pressure, moulded to any form, placed into interstices most difficult to get at by any other method, and is reliable under almost any conditions. Although applicable to any form of shaft, it is particularly adapted to those of curvilinear form. Concrete dams for holding back water under high pressure have been successfully built, for they are strong and impermeable.

The ultimate shaft capacity must have reasonable relation to the area to be exploited; the lower the grade of the ore and the more variable the distribution of its valuable content within the accepted limits of payability, the larger the area it is expedient to provide for.

to 30,000 tons of ore per day. There would also be one cage shaft and one ventilation shaft; these would provide for all the usual services. It would be expedient to have in the skip shaft a circular (or elliptical) self-contained compartment for the free passage of the air current, as the movement of the skips tends to retard the flow of air. Both cage and skip shafts would be downcast, in order to avoid the trap necessary when the upcast fan shaft is needed for hoisting purposes.

The ventilation of a large property at some

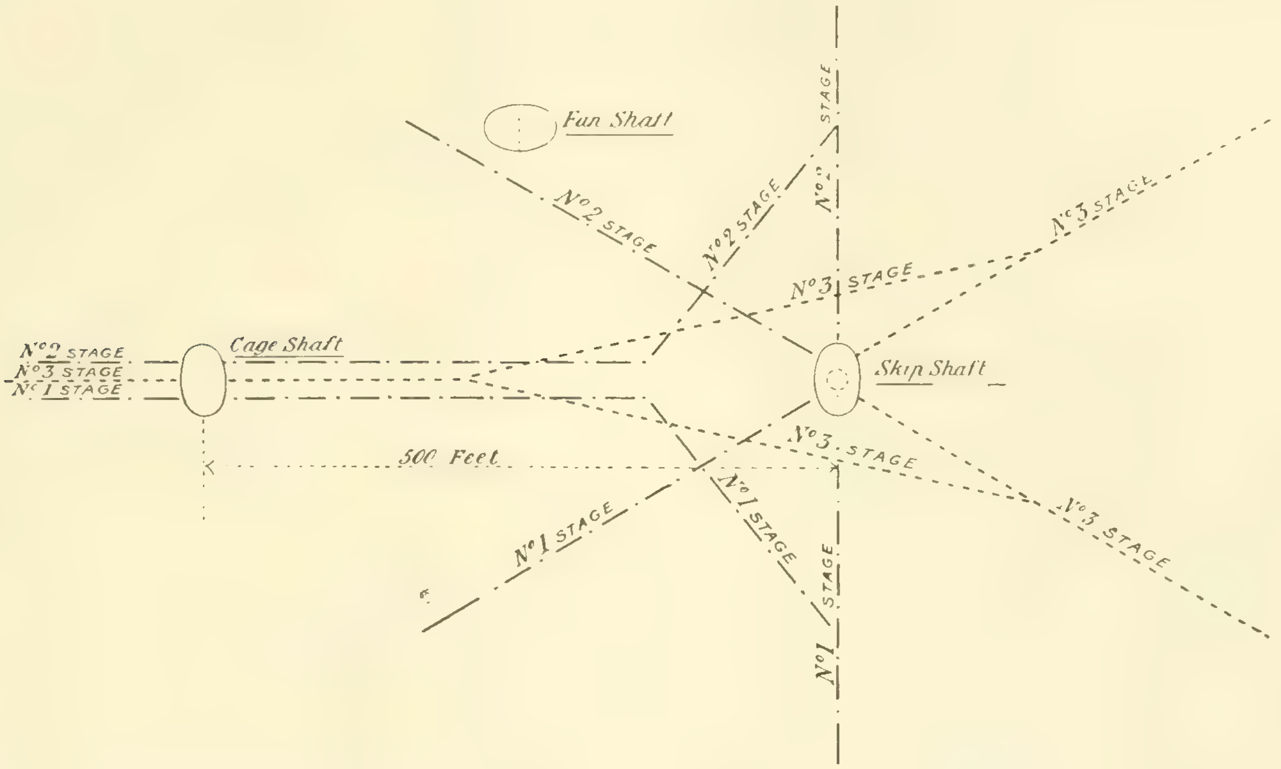


Fig. 2. Suggested Lay-Out of Shafts and Main Roads.
Return Airways and Connecting Travelling-Ways to be set out to serve Six Districts.

The hoisting of mineral not subject to deterioration through rough and repeated handling is generally most satisfactorily done by skips of the self-dumping type. Minimum time is required for loading and discharging, so the actual hoisting time is higher than in cases where cages are adopted. The shaft transport of men, stores, and materials is, if possible, best done by cages. The efficient use of shaft capacity depends largely upon loading and unloading the shaft carrier; hence it is best to use skips for ore and cages for the other services. This will lead to economy as well as efficiency.

There is not any uncommon engineering difficulty to be faced in sinking and equipping elliptical shafts of large capacity. One shaft would carry six double skipways or three double cageways, and deal with from 25,000

depth calls for exhaust fans of big capacity and an independent shaft. This should have two compartments, a fan for each. This shaft would be the main way to and from the mine for all workers travelling in or out between shifts, so as to relieve the cages as well as to facilitate arrangement of the work. The actual travelling-way would have to be wide enough for four men to travel abreast, and it would need a supply of fresh air which could be taken from drives used as intake airways.

Surface arrangements to deal with skip-hauled ore on a large scale may be most conveniently grouped radially around an elliptical shaft. Assuming that banking-out is to be done at three stages, the disposition of bins to take the contents of the skips and of the conveyors and sorting belts moving the ore to crushers or to storage bins, as well as the winders, headgears, etc., can be so laid out that economical handling is assured. Everything will be simple as well as symmetrical. All structural work can be done in reinforced concrete, giving best-class work at a minimum cost, and possessing a maximum of advantages and safety.

Surface arrangements at the cage shaft, to deal with three double cages, would be laid out to suit transport of stores, material, etc., to be sent underground. The three stages here will permit roads to be so laid out that crowding will be avoided. The winders will be arranged one on one side with two on the other side. Banking work will be simple. Roads will run direct to the shops and the stores and materials yards, so that one loading of requirements will suffice, thus avoiding the transferring which is so much in evidence at most mines. Cages to take anything up to 15 ft. in length will enable loads of drill steel to be taken direct from the smithy to a convenient point for distribution in the mine.

The lay-out at the shaft stations provides for working at three stages about 30 ft. apart. Any dip of the measures will favour such an arrangement.

At the skip shaft each skip would have independent ore pockets taking the ore as discharged from the mine cars. The pockets would be cut out at a sufficient distance from the shaft to avoid any weakening of the shaft wall. Their capacity would be limited only by the length of the conveyor adopted. From the pockets the ore would pass to plate conveyors set at an angle in favour of the load, with a width of about 4 ft.; these would deliver into loaders of sufficient capacity to load each skip in a few seconds. Such an arrangement of pockets, conveyors, loaders, and skips would make for very rapid hoisting. One advantage of the three-stage arrangement at the bottom of the shafts is that the shaft side at the position of the station would not be weakened to any serious extent.

At the cage shaft station each pair of cages would have ample road accommodation for heavy traffic. It may be expedient to have an intercommunication shaft with travelling-way connecting the three stages at a point near to the cage shaft, to facilitate the interchange of traffic between the different levels.

The general transport system would have 30 in. gauge track, with rails from 30 to 40 lb. weight. The mine cars would be of about 3 tons capacity. There would be electro-motors for haulage on all main roads. In view of the wide distribution of the working places, the mine workers should be transported to and from points near their work.

Underground operations on this scale may call for modification of the shift arrangement. A system may be devised under which the men working on contract may go to and from their work at hours more suitable than the regulation change-shift times generally followed.

FAR EAST RAND AND HEIDELBERG DISTRICT

THE SHUI-KO-SHAN ZINC & LEAD MINE

IN HUNAN, CENTRAL CHINA.

By A. S. WHELER AND S. Y. LI, A.R.S.M.

The authors give particulars of a mine in Central China, operated by modern methods. The figures relating to costs are of special value.

INTRODUCTORY.—The mineral production of China, excluding iron and coal, is the aggregate resulting from numerous small mines of the type that can probably be best described as "native workings." The "wholesale system" in mining has never yet been practised, and there are, at the present time, no mines under Chinese control in any way comparable to the big or even moderate sized producers of other countries. The majority of these small mines keep no proper records of either outputs or costs, while from those that do it is not often that a detailed statement of costs can be prepared, or is procurable. Judging by our experience in visiting and examining mines in various parts of the country, the average mine manager possesses no technical qualifications or experience fitting him for his post; he rarely ventures underground or is conversant with the details of the treatment process, while his ideas of output and costs are usually very hazy. The general lack of information on this all-important subject is most deplorable; and the meagre amount that is available is quite inadequate as a basis on which any reliable estimates of costs could be framed or on which one can generalize.

During the course of a tour of inspection in Hunan province, the authors had occasion to examine the Shui-ko-shan zinc and lead mine. This property, which is the largest and foremost of its kind in China, was found to be one of the very few where operating costs are recorded with any degree of accuracy, or in sufficient detail to permit of analysis. In preparing this account of it, our main object has been to give figures of cost of production which, although they cover only a brief period of four months, may prove of interest and value as a record.

Hunan is one of the provinces of southern central China, and lies on the south side of that great artery of commerce, the Yangtze river, which forms a portion of its northern boundary. It is perhaps better equipped with navigable waterways than any other province of China, three rivers, the Siang, the Tze, and the Yuan, flowing through it, and all emptying into the Tung-ting lake which communicates with the Yangtze.

The Shui-ko-shan mine is owned by the Hunan Official Mining Board, and is practically their only profit-earning mining venture, carrying the burden of a number of other properties mostly operated at a loss. Existing records, the earliest of which date back to the latter end of the Ming dynasty (circa A.D. 1600), prove that the mine has been worked spasmodically for the past 300 years. Toward the close of the last century operations were brought to a standstill owing to the difficulties and cost of working at depth, and in the 23rd year of Kuang Hsü (A.D. 1897), during the late Empress Dowager's regime, the then Governor of Hunan, hearing of the mine, established what is practically the present Hunan Official Mining Board and re-started operations. It was soon realized, however, that if the venture was to be a success, native methods would have to be replaced by modern practice; consequently the present incline shaft was started with the object of modernizing the underground workings. In 1912 the mine was reorganized and the "foreign" dressing plant put in commission. The money for this was obtained by a loan from Messrs. Carlowitz & Co., of Hankow, under contract to sell to this firm the entire output, one-third of which was to be paid for on delivery and the balance taken in repayment of the loan, until fully redeemed. This contract is understood to have since been cancelled.

The mine is situated a few miles south of the Siang river in the Chang-ning *hsien*, or magistracy, of the Hengchow *fu*, or prefecture, being 90 li (32 miles) south of Hengchow city. It is well placed as regards transport facilities. Between the village of Sung-po, which is the loading station on the Siang river, and Hengchow all river freight is junk-borne. From Hengchow to Changsha (155 miles) small Chinese owned launches are usually available. Between the treaty ports of Changsha, the capital of the province, and Hankow (250 miles), a regular service of river steamers, drawing from 5 to 6 ft. of water, is maintained, but has usually to be suspended during the low-water season, from about December to March, when only shallow-draught launches and Chinese junks can pass. Big river steamers run all the year round between Hankow and Shanghai (600 miles) and during the high-water months, May to September, ocean-going steamers can often proceed up the Yangtze to Hankow. An easy and cheap means of transport is therefore provided between the point of production and the seaboard, such as is not often available in this country.

From Sung-po a light railway runs $10\frac{1}{2}$ li (3·8 miles) south to the mine. The track is built to 60 cm. gauge, with 20 lb. rails, and carries a full load of fifty tons, consisting of a train of fifteen trucks of concentrates plus engine; coal and general supplies are brought back on the return trips.

GEOLOGY. — The geological structure, though interesting, is not of an uncommon type, and, in its main features, is similar to many well known deposits. The ore carrier is limestone, of the series generally known as the "Great Limestone" formation, and is ascribed to the Paleozoic to Mesozoic periods. It is probable that this limestone may be classed as belonging to the Carboniferous era. Overlying this are red sandstones and shales of Cretaceous or Tertiary age. These cover the area to the north and west, while the limestone prevails on the south and east sides. The contact of the two series may be observed about $1\frac{1}{2}$ li (0·54 mile) north of the main incline shaft showing slight unconformity, the dip of the superimposed red sandstone being 50° ENE as against 70° of the limestone. An eruption of syenite, apparently laccolitic in nature, has tilted both formations, producing an anticline, the crest of which has since been denuded, exposing the intrusive core and also an igneous breccia of limestone fragments resulting therefrom.

The occurrence consists of large irregular shaped bodies of ore composed of zinc blende and galena, with both iron and copper pyrites, developed in the limestone at or near the contact with the syenite. The chalcopyrite also occurs in the form of small crystals disseminated through the syenite and would appear to have formed an original constituent, while the deposit itself was the direct result of metasomatic action of the mineral-bearing solutions emanating from the magma. The presence of well marked slickensides and a crush conglomerate composed of ore and matrix testify to considerable subsequent pressure and movement. The igneous breccia which marks the line of contact, merging on the northeast side into limestone, and on the southwest into syenite, is quite distinct from the crush conglomerate.

The accompanying plan of the fourth level shows all these features clearly, and also the line of ore deposition, which roughly follows a curve from southeast to west. Prospecting was in progress at two other points in the vicinity, where the geological features are similar, but no big orebodies had been found.

PLAN OF THE FOURTH LEVEL, SHOWING THE GEOLOGICAL FEATURES AND OREBODIES.

MINE WORKINGS. — The mine, which until 15 years ago had been worked entirely by primitive Chinese methods, was then reorganized and run on more or less modern lines. A main 3-compartment shaft, measuring 11 ft. 6 in. by 6 ft. 6 in. within timbers, was sunk at an angle of 51° through the old workings to a vertical depth of 500 ft., and four levels were driven at 290, 400, 440, and 500 ft. respectively. A vertical 10 ft. by 6 ft. 6 in. winze, sunk 164 ft. below the fourth level, serves the 5th and 6th levels, the latter being the bottom level.

There were still two native mines, one of which was worked through an opening connected with the main workings, the other being on a detached orebody on which work was temporarily suspended pending the sinking of a new vertical shaft, which had recently been started. This shaft measures 13 ft. 9 in. by 6 ft. 10 in., has three compartments, two for hoisting, and one for pump and ladder way.

MINE COSTS.—We found that all work was done on contract as is usually the case on Chinese mines. Machines were not used for sinking, driving, or stoping, although a 60 h.p. compressor and twelve rock-drills formed part of the mechanical equipment.

The prices paid per foot for sinking were:

	Mexican Dollars	s. d.
New vertical shaft 15 ft. 6 in. by 8 ft. 6 in.	10·05	16 9
Incline shaft 13 ft. by 8 ft.	8·87	14 9
Vertical winze 11 ft. 6 in. by 8 ft.	8·87	14 9

The shaft setts were of 8 in. square imported pine, and the cost of fitting and fixing including lagging and ladders was given at 0·30 Mexican dollars (=6d.) per foot of depth.

The contract prices for driving, 6 ft. 6 in. by 6 ft. 6 in., were per foot advance:

	Mexican Dollars	s. d. s. d.
In syenite or breccia	4·14 to 5·32	6 11 to 8 10
In limestone	5·32 to 7·10	8 10 to 11 10
In tough limestone	7·10 to 8·87	11 10 to 14 9

including tramming of ore to shaft or disposal of waste in old stopes. It may be mentioned here that the expenditure on development was kept very low. The Chinese do not appreciate the necessity of development, and it is rarely that any ore is held in reserve in a mine operated under Chinese control. The almost universal practice is to work out the ore as found, and hence when a poor zone is encountered the mine has to be closed down unless further capital is forthcoming. The Shui-ko-shan was, however, an exception to the rule, and the ore in sight in the mine together with the reserve at surface was about sufficient to supply the treatment plants then working for one year. Hand stopers were paid 36 cash per picul (=9·13d. per ton) of rough sorted ore trammed to shaft; if the ore had to be carried up to the level a few cash extra were given. Whether sinking, driving, or stoping the contractor had to find his own powder, and could purchase food from the company at reduced rates; the company providing all other necessaries. The explosive used was native-made black powder and cost $0·133 per catty, or 2·02d. per lb. Ore carriers, in native workings, were paid 142 cash (being 82 cash as wages and 60 cash food allowance) for a minimum of 11 piculs of ore per 8-hour shift; this is equivalent to 2·12d. per 1,450 lb., or at the rate of 3·27d. per ton. For each additional picul 18 cash was paid; this in sterling equivalent is 0·27d. per 131·6 lb., or at the rate of 4·56d. per ton.

We found that there was little or no timbering in the stopes; the walls stood well and there had been a fortunate freedom from falls of ground in the old workings.

The following were the wages paid per shift:

	Dollars and cents	Shillings and pence
Pumpmen, working bamboo suction pumps in the native mine	24·25 to 53·35 c.	4·85 to 10·67d.
Surface coolies	11·64 c.	2·33d.
Ventilation (by windbox) men	24·25 c.	4·85d.
Carpenters and timbermen	19·4 to 33·95 c.	3·88 to 6·79d.
Masons	17·46 to 24·25 c.	3·49 to 4·88d.
Stokers	38·8 c.	7·76d.
Blacksmiths	48·5 c.	9·7d.
Fitters	$0·485 to $1·455	9·7d. to 2s. 5·1d.
Hoisting engine drivers	$1·455	2s. 5 1d.

Eight-hour shifts were worked underground, and 10-hour at surface.

The labour force at the "foreign" mine totalled about 800, of whom one quarter were surface hands, including blacksmiths and mechanics. The native mine employed about one-tenth of this number. The average daily wage worked out rather over 20 cents (=4d).

The tonnages hoisted per month averaged 6,375, of which 5,497 came from the "foreign" mine.

The total mining cost per ton to the company was $1·80 (=3s.) apportioned as follows:

	Mexican Dollars	s.	d.
Wages:			
Development	3·152		3·04
Stoping	0·457		9·14
All other work	0·232		4·64
Mine supplies, excluding cost of timber and rails:	0·659	1	1·18
Prospecting:	0·300		6·00
Total	$1·800	3	0

ORE TREATMENT.—The hoisted ore was subjected to a preliminary cobbing and sorting, and at the same time classified into lumps, coarse, and fines. The lump ore was then cobbed and close-sorted, yielding clean galena and zinc-blende ready for shipment. The sorting arrangements were very poor, which explained the relatively high cost per ton of this item. The ore was trammed from the shaft top and dumped in front of a big dimly-lit sorting shed, into which it was carried in baskets to be cobbed and close-sorted by boys. Portage from the shaft to sorting shed cost $0·032 (=0·64d.) per ton. Cobbing and sorting was paid for at 13 cash per minimum of 55 catties of picked ore (=0·194d. for 72·5 lb., or at the rate of 6d. per ton), plus 80 cash (=1·19d.) food allowance. For each additional 5 catties, 5 cash extra was paid (=0·075d. for 6·6 lb. or at the rate of 2s. 1·4d. per ton). This hand-picked ore constituted more than half the total output.

The remaining lumps and coarse (+ ¼ in.) were sent to the "foreign" dressing-floors, and the fines to the Chinese floors. The flow-sheet on the following page outlines the treatment process at the foreign dressing-floors, and the figures in the table below show the normal range in grade of the concentrates produced.

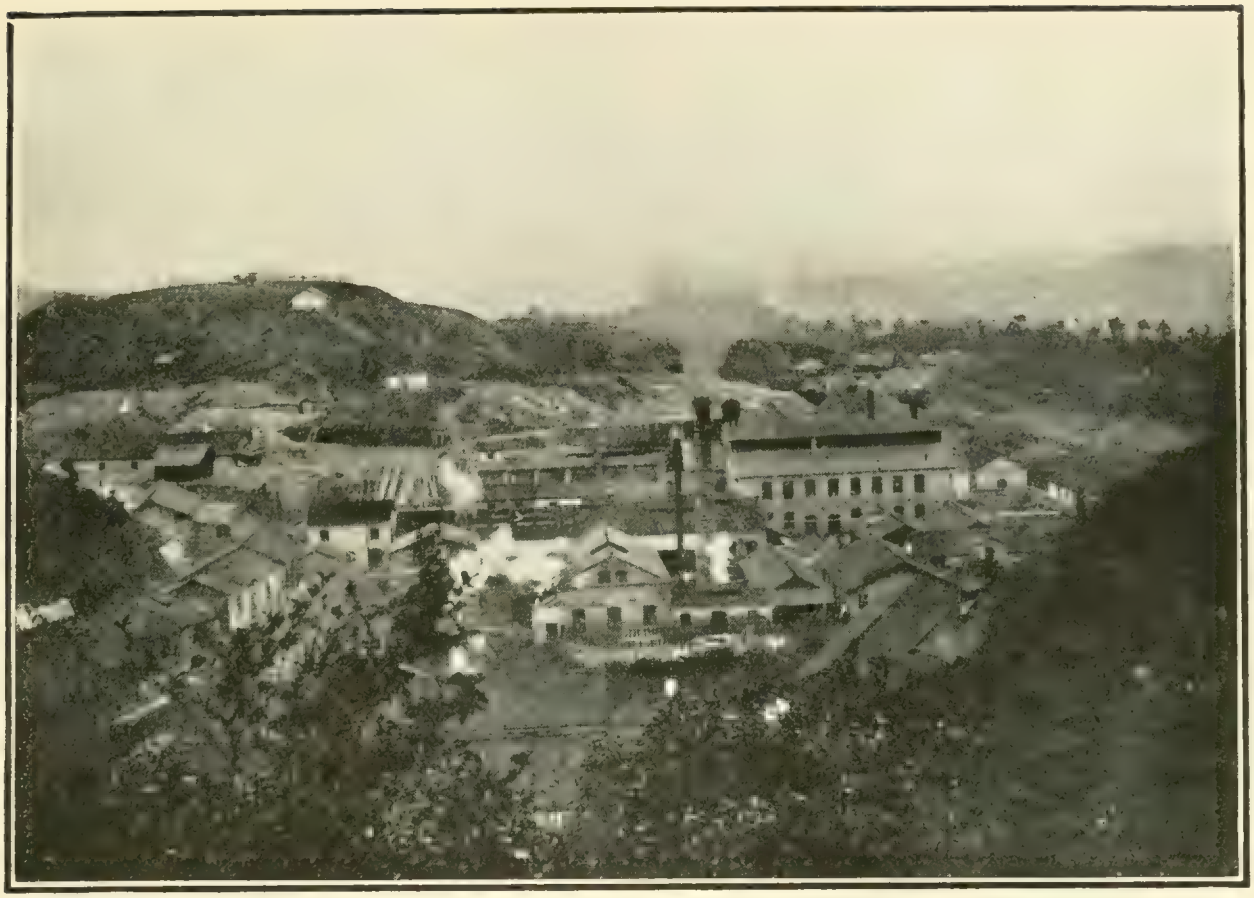
The results of mechanical and hand concentration, as we saw them, formed an interesting comparison. On the Chinese floors the ore was concentrated by hand-jigging in shallow baskets immersed in water. After a few pulsations, the operator gave the basket two or three short abrupt twists which brought the waste to the top. He skimmed this off with a scraper and repeated the process, rejecting an upper skimming of waste and throwing on to a heap a second skimming of mixed product. When sufficiently reduced, the concentrate was thrown out on to the earth floor and crushed by beating with a flail (precisely similar to our old fashioned corn thresher); it was then hand-jigged over again, yielding a final lead concentrate and a mixed product. The latter was similarly treated until the galena had been eliminated as far as possible, leaving a zinc concentrate. The tub sludge or sediment, which carried about 27% Pb and 13% Zn, was concentrated by repeated washings down a concave inclined plane built of stone and cement-faced. This process may be regarded as equivalent to buddling. The sludge was packed in a layer at the top of the plane, and the dresser, seated at the lower end, flicked up jets of water in rapid succession with a small bamboo scoop, washing down a little ore with each jet. The waste was carried down to the bottom of the plane or washed off, the concentrate settling higher up. When the whole layer had been thus treated, the heads were collected and the process repeated on the tails. The method was extremely crude, and more or less independent of the skill of the operator; the product could probably have been far better handled by the Wilfley.

With this exception the figures show that a rather higher degree of concentration was being obtained by the Chinese hand methods than by the mechanical appliances in use.

The capacity of the "foreign" plant, at 50 tons per day, was slightly in excess of that of the Chinese floors. A new plant, designed to handle 100 tons daily, was in course of erection at the time of our visit, and has since been put in commission.

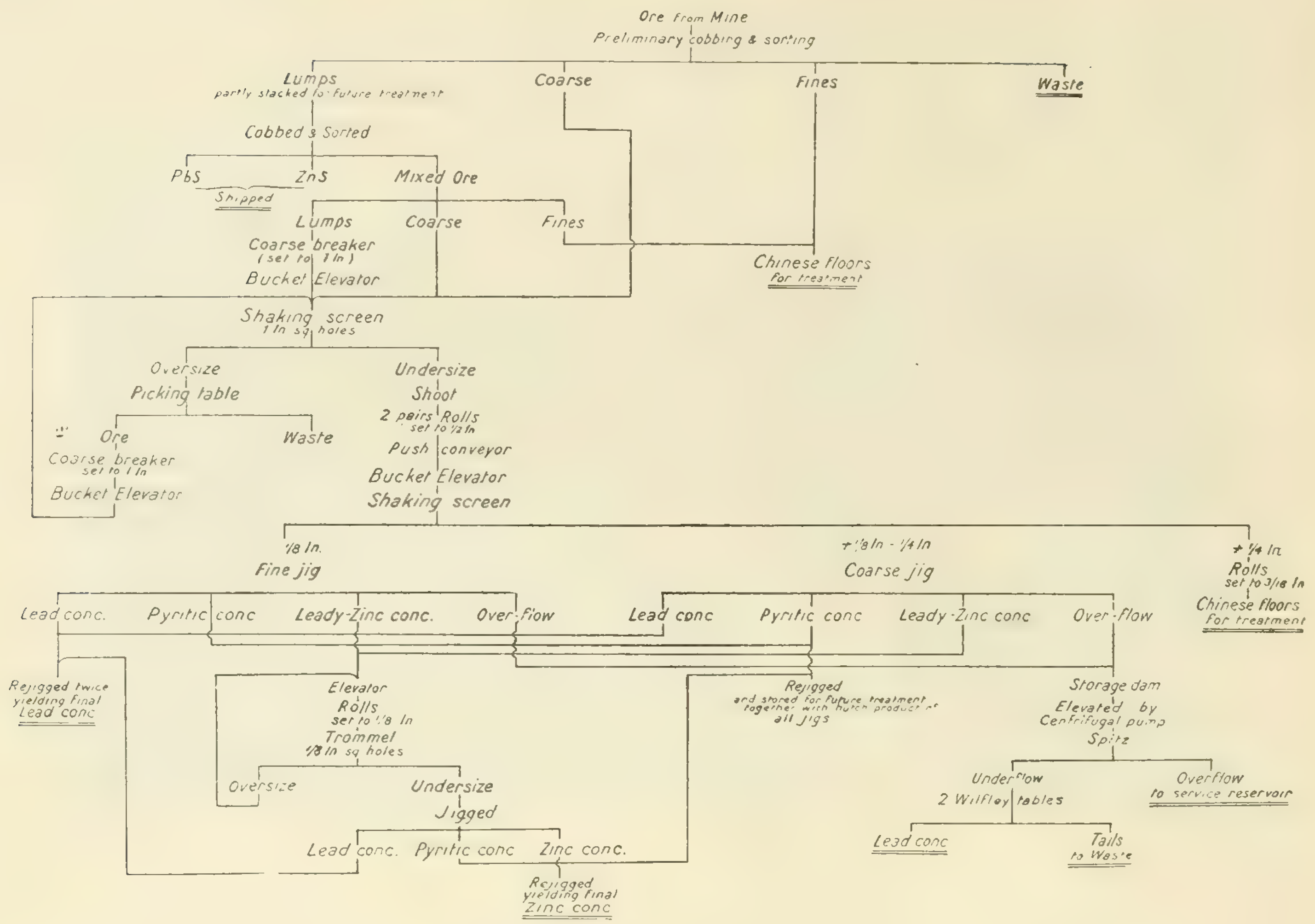
	Lead Concentrate			Zinc Concentrate		
	Pb %	Zn %	Ag Oz. per Ton	Zn %	Pb %	Ag Oz. per Ton
Picked ore	67 to 73	under 5	17 to 30	38 to 53	2·5	up to 4
Jigs	65 to 75	7	20 to 37	24 to 28	7 to 15	up to 13
Wilfleys	71 to 79	5	29 to 38	—	—	—
Chinese floors:						
Fines	56	11	9 to 12	26 to 36	5 to 13	4 to 24
Coarse	67 to 75	7	21 to 25			

Middlings from jigs stored for future treatment averaged about 16% Pb and 16% Zn; and the tailings about 3% Pb and 8% Zn.



View of the Power House and Main Incline Shaft.

View showing the New Mill in Course of Construction.



FLOW-SHEET AT THE MODERN DRESSING-PLANT AT SHUI-KO-SHAN MINE.

The figures of tonnage of ore treated and output during the period under review are:

	Tons
Average tonnage treated per month	5,483
Average output of concentrates per month	2,274

Details of Concentrates:	Lead	Zinc
Hand picked	334	961
"Foreign" plant	123	418
Chinese floors	100	338
Totals	557	1,717

The cost of treatment was: per ton of ore treated $1·05 (= 1s. 9d.); per ton of concentrates produced $2·53 (=4s. 2·6d.); of this latter figure $2·15 (= 3s. 7d.) was paid in wages and food. Attendants in the foreign plant, of whom there were three each 10-hour shift, were paid from $1·40 to $2·00 (= 2s.4d. to 3s. 4d.) per shift.

Accounts kept in more detail during one month showed the following costs per ton of dressed ore.

Produced by:		
Hand-picking	$2·25	(= 3s. 9d.)
"Foreign" plant	$1·10	(= 1s. 10d.)
Chinese floors	$3·30	(= 5s. 6d.)

These figures do not include staff salaries, repairs, or power, and it is not possible to segregate these items from the accounts, though they are included in the subsequent figures given of total running costs.

TRANSPORT.—Transport costs worked out at $1·272 (= 2s. 1·44d.) per ton of concentrates produced, and were made up as follows:

Railage from mine to Sung-po 3·8 miles	$0·313	(= 6·20d.)
Loading aud unloading cars	0·090	(= 1·80d.)
Loading boats	0·045	(= 0·90d.)
River freightage Sung-po to Changsha (185 miles)	0·827	(= 1s. 4·54d.)
	$1·272	(= 2s. 1·44d.)

There were no loading facilities at Sung-po; the concentrates were tipped from the trucks, shovelled into baskets, and carried by coolies down the river bank to the junks, which conveyed them to Changsha, where Carlowitz & Co. took delivery.

MECHANICAL EQUIPMENT.—Steam power was used throughout, and the boiler plant, consisting of four Babcock & Wilcox boilers, was generating about 600 h.p., burning a medium quality bituminous coal, mined in the vicinity and costing $6·30 (=10s. 6d.) per ton delivered. The monthly consumption averaged 1,500 tons, which figure included a certain amount used for domestic purposes. Semi-anthracite was obtainable from the Ping-hsiang colliery, situated in Kiang-si province, and connected by rail with Chü-chow, which lies on the Siang river 28 miles south of Changsha, at a cost of $8·75 per ton delivered, which included $1 freight charges. A little was used very occasionally in the small suction-gas plant, which served as an auxiliary drive for the electric lighting installation.

The mine was well equipped with engineering shops for pattern-making, moulding, fitting, and boiler making. Castings up to one ton weight were turned out, and steam engines and pumps were excellently made here under the direction of a most capable Chinese mechanical engineer, at about two-thirds of what the imported cost would have been; in fact half the machinery for the new plant was being made on the mine.

SUMMARY OF COSTS.—The administration was divided into two main departments: (1) general; (2) engineering. The former included general management and transport; the latter covered mining, prospecting, ore-dressing, assaying, surveying, and mechanical work.

The accounts were kept under the following headings and sub-headings:

HEADING	SUB-HEADING
Staff Salaries and Office Wages	Salaries of Manager and Assistant.
	Salaries of Officials (67 in number, ranging from $16 to $500 per month).
	Wages and food of office servants and bodyguard.
General Office expenses	Stationery.
	Postage and telegrams.
	Sundry office items.
	Miscellaneous (mostly loss on rice supplied to employees).
	Mine Police (about 70 strong).
Engineering	Mine labour (all underground workers).
	Mine supplies (timber, rails, steel, fuel, etc.)
	Prospecting.
	Ore-dressing (wages, food, supplies).
	Transport (railage and river freight from mine to Changsha).
	Mechanical.
	Railway (maintenance and repairs).
	Repairs to buildings
Erection and Purchase of Property	New dressing plant.
	Properties brought.
Miscellaneous	Miscellaneous.
Special	Gratuities, bonuses, and compensation for injuries.
	Apprentices and workshop expenses.

The figures thus given have been analysed and segregated as far as possible to cover the various items of cost, and may be summarized thus:

PERIOD—FOUR MONTHS

	COST PER TON			
	Ore Treated		Concentrates produced	
	$ (Mex.)	s. d	$ (Mex.)	s. d.
Mining	1·80*	3 0*	5·03	8 4·6
Ore-dressing	1·05	1 9	2 53	4 2·6
Transport	0·53	0 10·6	1·27	2 1·4
Mechanical	0·29	0 5 8	0·69	1 1·9
Fuel	1 72	2 10·4	4·16	6 11·1
Office	0 87	1 5·4	2·11	3 6·1
Sundry	0·64	1 0·8	1 55	2 7·0
Total	6·90	11 6·0	17·34	28 10·7

* Cost per ton mined has been taken, as balance was stacked for future treatment.

All new machinery or plant, other than made on the mine, and supplies such as timber, rails, &c., were purchased through the head office in Changsha, and do not figure in these costs; nor has any allowance been made for depreciation, &c. These additions would bring up the total cost per ton of concentrates to fully $20 or 33s. 4d.

OUTPUT.—The official records show that, from 1896 to 1912 inclusive, the mine had produced a total of:

Zinc concentrate .... 100,683 tons
Lead concentrate .... 41,837 tons

The pyrites in the ore was formerly collected and subjected to a process of roasting for its sulphur content, but this was stopped in 1914.

The full returns for 1913 and 1914 were as follows:

	1913	1914
Tons hoisted	42,570	64,474
Tons treated	46,037	55,087
Zinc concentrate	10,959	14,420
Proportion of picked ore in zinc concentrate	61·4%	58%
Lead concentrate	3,358	4,977
Proportion of picked ore in lead concentrate	50·4%	57%

NOTE.—For conversion from Chinese to British, the following equivalents have been used:

1 Chinese li	=	0·358 mile.
100 catties	=	1 picul.
17 piculs	=	1 ton of 2,240 lb.
1 Hunan dollar	=	1,500 "paper" cash.
,,	=	1,300 copper cash.
,,	=	0·97 Mexican dollar.
,,		1s. 7·4d.
12 Mexican dollars	=	£1 sterling.
1 ,, ,,		1s. 8d.

Figures of cost refer to Mexican dollars unless otherwise stated.

SPECIAL·CORRESPONDENCE

WESTERN AUSTRALIA.

MINING CONDITIONS.—The main point of interest to Australians recently has been the referendum on the question of conscription, and its aftermath in the shape of the coal strike at Newcastle. It is not necessary to dilate upon the policy or otherwise of submitting the question of conscription to the people, but the results may well be taken to heart in the analysis of the voting in the various States. New South Wales, Queensland, and South Australia, voted " No," while West Australia, Victoria, and Tasmania, voted " Yes."

For some years New South Wales has been very prosperous, and the Labour Ministry has spent millions of pounds in order to pander to the demands of its supporters for high wages and low efficiency. The result is that it has attracted the attention of the industrial workers of the world, and an organization has sprung up to defeat the imperial spirit which has been so strongly marked by the response to Britain's call since the war began. During the referendum campaign it was freely stated in the coal and silver mining centres of New South Wales that, if the referendum were carried in favour of conscription, there would be trouble on the mines when it was to be enforced. The influences thus brought to bear in these and other largely populated centres were sufficient to secure a preponderating vote against conscription in that State. This meant a disruption in both State and Federal Labour circles, which the coal miners in New South Wales used to foment a serious strike. This strike, after throwing all business into chaos in New South Wales, and to a lesser extent in the other States, has been declared off. The miners have been granted their main demand by the special tribunal appointed to hear the case on the question of eight hours from bank to bank, such time to be calculated from the time the first men left the surface, until the last men reached it again. The other demands are to be heard and decided by the same tribunal after the men have returned to work. The owners are to be compensated for any loss involved in giving effect to the bank to bank order.

The voting on the referendum in Western Australia is an indication of the better feeling between employers and the Labour Unions. Although the Miners' Union has been trying to have its case heard by the Federal Arbitration Court ever since the expiration of the last wages agreement some months ago, there is no talk of a strike at Kalgoorlie, and the officials of this Union recognize that they can do much more for their members by means of arbitration. The heavy enlistment of young men from the goldfields is beginning to make itself felt on the mines. The Oroya Links has found it necessary to curtail its operations, as it could not secure sufficient men to keep up development work. This, together with the heavy increase in the price of mine stores, made mining unpayable under the present conditions. The company has thrown open its Brown Hill and Oroya North leases to tributers, who are working on little blocks of ore which would not pay the company to work, and the royalty derived will enable development work in the Eclipse group of leases to be continued. Other mines are also feeling the strain, and it is only by the keenest and most economical management that several of these are able to keep going.

The settlement of the question of deducting the cost of development work in the assessment of profits, in respect of the year in which it occurred, by the State Taxation Department, is satisfactory. Advices have been received that some of the anomalies in the proposed Federal Taxation with reference to mines will be removed. The mines have already been heavily taxed by increased costs and are not likely to make any war profits. Taxation which may be fair to other enterprises would very soon cripple mining.

THE BULLFINCH COMPANY reports that owing to the recent excessively heavy rains penetrating the workings, a subsidence has occurred on the west side of the Southern series at the 310 ft. level. This will bring about a reduction in mill tonnage two months earlier than expected, as it would have been necessary to reduce the mill tonnage in January next.

WESTONIA.—The Edna May company has now completed the installation of the large new Worthington pump and the Cornish lift at the No. 5 (385 ft.) level, which will be able to deal with half-a-million gallons of water per day. The recent increase in the quantity of water coming into the workings has necessitated this addition. The cross-cut at this level has been driven 60 ft., and it is expected to cut the lode in another 100 ft. At this depth in the shaft (385 ft.) a granite bar was cut, but after sinking to 406 ft. the greenstone came in again.

The Edna May Central treated 2,750 tons of ore for a return of £4,426 during November, and the total expenditure including development and plant was £3,923. An interesting discovery has been made on this mine. The manager put a cross-cut into the south bank of the alluvial wash, and discovered another run of wash containing a different type of quartz and coarser gold. Sufficient work has not yet been done to prove the extent or grade of the deposit.

Edna May Deep Levels cleaned up 370 tons for a return of £1,500. The mining and milling expenditure was £890. The ore was obtained from the 480 ft. level. The Edna May Consolidated company has cut what is believed to be the Edna May central lode, and it is understood to be good grade. Owing to the alterations necessary to the main shaft, the work of opening up this lode will be deferred for some time. The heavy flow of water met with in the lodes on this belt of country is so great that it is imperative that the main shafts be timbered very securely, otherwise there is the danger of losing them, an experience which happened in the early days of this field.

JOHANNESBURG.

Mining Dividends.—The dividends declared by the gold-mining companies for 1916 total £7,095,061, as compared with £7,619,416 for the previous year. The fall may be attributed principally to the higher costs of stores. Striking reductions in the dividends declared are noticeable at the Crown Mines, East Rand Proprietary, Ferreira Deep, Langlaagte Estate, New Kleinfontein, and the Robinson, which have been far from neutralized by the higher dividends declared by the City Deep, Modder B, and Modder Deep. All the outside district mines save the Sub-Nigel have also done badly in 1916, while among the coal and tin companies the dividends distributed last year were about the same.

Barnato-Robinson Deal. — What is called locally the Randfontein deal is very popular on the Rand. It is thought that the passing of the control of the Langlaagte and Randfontein properties into the hands of the Barnato group will restore the Western Rand to popularity, this section of the Rand having fallen into the doldrums ever since the Lancaster properties turned out such a failure. The amount paid to Sir J. B. Robinson for his controlling interest in the Langlaagte and Randfontein properties has not been made public nor is it likely to be. In some quarters it is thought that the amount might nearly reach the £3,246,000 paid by De Beers in 1888 for the diamond-bearing claims, while others place the amount as low as a million. No doubt Sir J. B. Robinson has done well to get quit of the worries in connection with the Randfontein property which, although it has been well equipped and brought to such a state of production as to occupy for the last year the proud position of premier gold producer on the Rand, has proved very disappointing from a dividend-paying point of view. In this Sir J. B. Robinson has been a victim of circumstances, seeing that originally the Randfontein farm is said to have cost only £7,000. The acquisition of neighbouring farms, nursing the properties for thirty years, equipping the different mines as producing units, amalgamating into two concerns and later into one producing company, have resulted in the growth of such a large capital that satisfactory dividends seem to be quite out of the question. It will be interesting to see what steps the Barnato group will ultimately take to overcome this difficulty. Owning properties in the neighbourhood of both Langlaagte and Randfontein, the group will probably take some decided action. Both the Randfontein and Langlaagte properties appear to have long and prosperous lives in front of them, and as the Barnato group has the credit of possessing financial talent of no mean order, and is likely to be increased by the accession of a noted financier in the immediate future, the handling of the properties is looked forward to with considerable interest.

East Rand Proprietary. — Still more troubles persist in coming for the East Rand Proprietary Mines. In a recent letter I described a novel method of prospecting proposed to be adopted of driving in 6,000 ft. of dead ground to prove the reef lying to the dip of the Angelo Deep Shafts. This consisted of driving two converging cross-cuts from the No. 27 level, and at the point of intersection sinking a vertical shaft to the reef some 2,000 ft. in depth. The boldness of such a scheme certainly deserves success, but already there is trouble on the board of directors with regard to the wisdom of the scheme, and one of the directors has in consequence resigned. The cross-cutting had no sooner started when what is described as an underground river was encountered, necessitating the construction of dams. Fortunately the pumps are able to deal with the increased inflow, but it is evident that the cross-cuts have not, as anticipated, been able to avoid the water-logged strata. The general opinion here seems to be that although the progress would be tantalizingly slow it would have been better to continue the incline shafts in the foot-wall of the reef, and have something to show for the huge expenditure of capital which the proving of this dip ground is sure to cost. Developments are reported as failing to improve, and undoubtedly the prospects of this huge property are none too bright.

New Slime Process.—Since the failure of the Way-Arbuckle process at Benoni, little has been heard on the Rand of new processes of treatment, but some enthusiasm is being shown locally with regard to a new process of slime treatment. At the annual meeting of the Mauss Continuous Centrifugal Separator, Ltd., held at Johannesburg the other day, the Chairman stated that a machine had been erected at the Zaaiplaats tin mine and that the results had more than equalled expectations. The invention is described as consisting of a drum 4 ft. in diameter revolving at the rate of 500 revolutions per minute on a fixed shaft, into which the pulp is fed direct. Two other circular drums are fixed inside, which revolve in the opposite direction at the rate of 100 revolutions per minute. The action of the machine is to readily separate the solid matter from the liquid, which flows off as in a cream separator, the solid matter being deposited on the face of the two smaller drums. This product is afterwards treated on Frue vanners, and already a 60% extraction has been obtained at Zaaiplaats as against 25% extraction at Rooiberg, where a special plant was some time ago erected to deal with the current slime. It is expected that an extraction of 75% can be obtained by preparing the slime before treatment. The process can with modification be adapted to the treatment of many other products. [The process resembles in its main features the Gee process which was tried some years ago in Devon and Cornwall in connection with tin and china-clay.—Editor].

Trained Miners.—In a recent letter attention was drawn to numerous complaints about the lack of trained miners on the Rand. At the Chamber of Mines and company meetings the subject was discussed, while the annual report of the Wolhuter School, appearing at that time, caused increased emphasis to be placed on the subject. The report of the Wolhuter Miners' Training School pointed out that the efforts of the school were somewhat thwarted by the system of learners adopted by the mines on the Rand, but the Chamber of Mines has decided to put an end to this competition, and no more learners are to be taken on at the mines. A new board of control has been brought into existence, and additional training schools are to be opened in various parts of the Rand. It is hoped that by a concentration of efforts between these Government Miners' Training Schools and the Chamber of Mines a more efficient and satisfied miner will be evolved.

TORONTO.

Porcupine.—The year 1916 witnessed a remarkable expansion of the gold-mining industry of Porcupine and the outlying goldfields. Increased public confidence in the future of the district has attracted much American capital, and many new enterprises have been undertaken. The number of regularly producing mines has been considerably increased, and it is anticipated that before the end of the present year there will be at least 20 shipping mines in the Porcupine area proper, in addition to several in the outlying districts. The output of the Dome Mines during December was $183,000 from 39,000 tons of ore of the average value of $4·70 per ton, at a working cost of $2·77 per ton. The production during the year 1916 was $2,144,197. A better showing was expected, but operations were hampered by labour shortage and delay in machinery deliveries. A third ball-mill will shortly be in operation, with increased hoisting facilities, which should considerably increase production. A rich strike at the 700 ft. level is reported. The vein is stated to carry 50 ft. of high-grade ore, but official details have not been made public. The Hollinger Consolidated is now earning its dividends at the increased rate required by the merger. The gross profits for the 4-weekly period ending December 1 were $240,075 from the treatment of 50,304 tons of ore of the average value of $8·78 per ton, the working costs being $3·74 per ton. The deficit to be made up was $238,073. A unit of the new mill, consisting of 20 stamps, will shortly be completed, and is expected to be in operation early in March. This will increase the crushing capacity of the plant by about 300 tons per day. The merger of the McIntyre, McIntyre Extension, and Jupiter companies has been completed, and the capital of the company increased from $3,000,000 to $4,000,000. An orebody on the 1,060 ft. level of the McIntyre and the McIntyre Extension, varying from 20 to 40 ft. in width and assaying $20 to the ton, has been driven on for over 550 ft. An option has been secured by the company on the Plenaurum property. The quarterly report for the three months ending December 31 shows gross production of $356,504 and profits of $208,990. At the Schumacher a find recently made on the 200 ft. level has proved to be an important orebody about 9 ft. in width. The Porcupine Premier, otherwise known as the Standard, is being developed by Boston capitalists. A new plant run by electricity has been installed, and satisfactory ore is being opened up at the 100 ft. level. The shaft is being sunk to 300 ft. The West Dome is taking high-grade ore from the third level, and has now ore on the dump of the estimated value of $50,000. A double-compartment shaft is being sunk on the Tommy Burns. A vein with sulphides showing visible gold was found at a depth of 15 ft. At the Gold Reefs high-grade ore has been found in the shaft at the 50 ft. level. The main vein on the Davidson on the 300 ft. level is stated to have widened to 97 ft.

KIRKLAND LAKE.—The power line from Cobalt, upon which the mining plants in this district will be largely dependent, is nearly completed, and is expected to be in operation early in February. The main vein of La Belle Kirkland has been cut by diamond-drilling at a vertical depth of about 650 ft. and shows good milling ore 8 ft. in width. Two strong parallel veins have also been discovered, carrying fair gold contents. Sufficient ore has been proved to warrant the installation of a mill. The Minaker claims have been acquired by Boston interests. Buildings have been erected and surface exploration is being done. The Hunton Kirkland has been acquired by H. Cecil and associates, of New York, and active development will be pushed.

A NEW GOLDFIELD.—Despite the unfavourable season there has been an active interest taken by prospectors in Powell township, lying to the northwest of Elk Lake, where gold was discovered in November. Since then a number of prospectors have been there, some of whom have returned with favourable reports, backed by samples of their discoveries. Seventy claims or so have already been staked and an old-time rush is anticipated as soon as the snow disappears.

COBALT.—Productive activity is maintained owing to favourable market conditions for the silver output, but there have been comparatively few new developments in connection with the industry. The Nipissing during December mined ore of an estimated value of $259,836, and shipped bullion from Nipissing and custom ore of an estimated net value of $301,901. Test runs have been made at the flotation plant of the National Mines, which has about 40,000 tons of 7 oz. tailing, and the plant will shortly be in steady operation. The Coniagas flotation plant of 150 ton per day capacity is nearly ready and will be used to supplement the present milling treatment. At the Buffalo important new veins have been found on the first and second levels which have considerably increased its ore reserves. The McKinley-Darragh is sinking its shaft to the 400 ft. level for the development of new veins developed from a winze at that depth. The company has improved its financial position, having cash and ore on hand on December 26 to the value of $392,924. The Adanac shaft has reached the 400 ft. level, where a station has been cut and cross-cutting started.

CAMBORNE.

TRESAVEAN.—It is a matter for satisfaction that developments in the lowest levels at Tresavean mine are fully up to the expectations of the management, and it is hoped and believed that the faith of those backing the undertaking financially will be substantially rewarded in the not distant future. Captain Faull has tackled a difficult mining proposition in an able manner. The mines being owned by a semi-private company, little data are available, but locally it is recognized that, largely through the skill and energy of Captain Faull, the Lanner district is likely to again have a successful mine after a long lapse of years.

ST. IVES CONSOLS.—The properties known as the St. Ives Consolidated Mines have been purchased by a strong financial group, and the necessary capital for the adequate development of the Giew mine (which has given encouraging results up to now) will, it is expected, shortly be available. It is hoped in the next issue to give some information on the operations during 1916.

THE RESEARCH COMMITTEE appointed jointly by the Institution of Mining and Metallurgy and the Royal Cornwall Polytechnic Society has got to work, and samples of ores and concentrates from the various mines are being collected, while data as to content and recovery are being also secured. The tests are to be conducted at the Giew (St. Ives Consolidated) mill.

EXCESS PROFITS.—The first work undertaken by the Cornish Chamber of Mines is the collection of data from the various Cornish companies to enable an appeal to be lodged on behalf of the industry for an increase in the statutory percentage of profit permitted in connection with the Excess Profits Duty. It should be possible to construct a good argument in favour of a substantial increase in the case of home tin mines, for costs have heavily increased by reason of labour shortage and higher prices for material, without any compensating increase in the price received for the product; indeed, pre-war tin prices were substantially higher. The Board of Referees should be pressed respecting an allowance for wastage of capital to meet the gradual exhaustion of the mines; in Canada, such an allowance is permitted in connection with the Excess Profits Duty levied there.

WAGES V. ROYALTIES.—Within the Stannaries, wages are a first charge on the assets of a company, and recently there has been an interesting case dealt with in the Truro County Court, which are not settled quite in accordance with what was obviously the intention of the framers of the Stannaries Acts. The action was brought by the employees of West Kitty Mines, Ltd., for the recovery of £505 wages due to them. Recently, one of the lords of the Wheal Friendly section of these mines seized the machinery and plant thereon to satisfy his claim for royalties. When sold, the plant realized £592 more than was due to him for royalties, and the employees claimed the greater part of this sum in settlement of their outstanding wages. At the same time, the other mineral owners of the Wheal Friendly section asked the Court to earmark this £592 to meet royalties due to them. The Court decided to recognize the men's prior claim to this money, but did not actually award them the sum claimed, and the men will now have to apply to the High Court for payment. This is generally an expensive process and will result probably in a considerable part being dissipated in law costs. The procedure under the Stannaries Acts is perfectly clear and simple—purposely made so that employees should have an inexpensive remedy—and it is unfortunate that the Judge should have given such an unsatisfactory decision.

PERSONAL

ROBERT ADAMSON is expected home from Rhodesia.

A. F. S. ANDERSON, lately chief assayer to the Eastern Smelting Co., Penang, is with Australian Forces, stationed at present at Andover.

HOWLAND BANCROFT has closed his office at Oruro, Bolivia, and has returned to Denver.

A. BENNETTS has been appointed manager of the Edna May Battler mine, West Australia.

EDGAR BONDS is returning shortly to the Taquah mine, West Africa.

CHARLES BUTTERS has returned to San Francisco on the conclusion of his visit to England.

GEORGE B. BUTTERWORTH has been appointed manager for the South American Copper Syndicate, and has gone to Venezuela.

JOHN M. CAIRNS is returning from Baluchistan.

J. MORROW CAMPBELL is leaving on February 23 for Tavoy, Burma.

E. J. CARLYLE has returned to Sissert, Russia.

FRANCIS DRAKE has undergone operations at a nursing home in Lausanne, and is now convalescent.

A. GOLDWATER has returned from Nigeria.

W. FRANK GRACE, lately manager of the Waihi Grand Junction mine, died at a nursing home at Brighton, after a long illness. A mining engineer and chemist of conspicuous ability, he did excellent work at the mine and made it a profitable undertaking.

M. J. GRIFFIN is retiring shortly from the Government Inspectorship of Mines at Launceston, Tasmania.

W. T. HALLIMOND is back in South Africa after a long trip to England and America.

HERBERT C. HOOVER is paying a visit to the United States.

THEODORE J. HOOVER has opened an office in Mills Building, San Francisco.

MARK R. LAMB, for many years representative of the Allis-Chalmers Co. in South America, has resigned and has returned to the United States.

F. W. LINCK has gone to Burma.

WALDEMAR LINDGREN, Professor of Economic Geology in the Massachusetts Institute of Technology, is on his way to South America.

F. J. MARTIN is expected from the Malay.

C. T. NICOLSON has returned from Siberia, where he has been engaged on work connected with the Cabinet mines.

W. PELLEW-HARVEY has returned from Australia.

GASTON PREUMONT has left for Bolivia.

R. K. STOCKWELL, who has been chief engineer and superintendent of construction for the Braden Copper Co., Chile, for the last five years, has returned to the United States and is opening a western engineering and sales office at Salt Lake City for the Robins Conveying Belt Company.

We regret to record that R. GRYLLS THOMAS has died of fever in Nigeria.

W. E. THORNE is expected from the Lena goldfield.

R. C. N. TWITE and DONALDSON AIKIN have entered into partnership, with offices at Tavoy, Burma. Dr. O. J. STANNARD will represent them in London.

H. A. VAUDEAU, who is at present the manager of Block 14 Co's scheelite mine on King Island, has been appointed an Inspector of Mines for Tasmania.

A. S. WHELER, lately mining adviser to the Chinese Government, has returned home, and has received a commission in the Royal Engineers.

ERNEST R. WOAKES has gone to South America.

WILLIAM R. WRIGHT is coming home from Ropp, Nigeria.

METAL MARKETS

COPPER.—The edict taking over the supplies of copper in this country on behalf of the Ministry of Munitions was followed by an immediate and substantial drop in prices. It is a moot point as to how much of the drop was occasioned by the scurry on the New York stock market, and how much by the new regulations. Electrolytic copper, however, has been officially recorded down to £138, for of course there are no actual dealings. American demand eased off. Whereas buyers had been hard pressed to find supplies for the orders offering, they suddenly appeared anxious lest they should find themselves loaded up at top prices. Prices consequently fell to 27 to 28 cents New York. From this level values rallied and 32½ to 33½ cents was asked at the close of January. In this country the rally took the electrolytic quotation up to £145 to £142. The future of the market is entirely bound up with political considerations.

Average prices of cash standard copper: January 1917, £131. 16s. 9d.; December 1916, £145. 9s. 2d.; January 1916, £88. 2s. 11d.

LEAD.—There is no change in the official quotation. Shipment is exceedingly difficult from Spain, and substantial quantities are lying at shipping ports awaiting steamers. In America the price has risen to 8 cents. This metal has now come under more effective control of the Ministry of Munitions.

Average prices of spot foreign lead: January 1917, £30; December 1916, £30; January 1916, £30. 17s. 5d.

TIN.—The market has shown strength, and substantial rises in official prices are registered. Some very high levels have been reached in New York, where the demand for spot tin has become acute. January shipments from the Straits, estimated at 6,000 tons, only reached 4,500 tons owing to the scarcity of freight space. On the other hand deliveries in America total the substantial figure of 7,000 tons. Batavia has raised its ideas and has been realizing good premiums for American shipment. Home demand is quiet, but pretty good buying has come from Allied countries. English makers are well sold and full prices are being paid.

Average prices of cash standard tin: January 1917, £186. 6s. 4d.; December 1916, £183. 9s. 1d.; January 1916, £175. 16s. 4d.

SPELTER.—This metal opened the year weak, and prices fell to as low as £45. 10s.—£42. The continued weakness in America had produced a feeling of general distrust. The low level, however, attracted buyers, and with their advent prices again rose rapidly, and £53. 15s.—£51 was the official figure at the end of January. In face of the shipping difficulties prices are thought reasonable. Trading is slow, as neither sellers nor buyers care to take the responsibility of shipment.

Average prices of good ordinary brands: January 1917, £48. 8s. 3d.; December 1916, £54. 5s. 9d.; January 1916, £83. 12s. 5d.

NICKEL.—£225 per ton. In the United States the price is 45 to 50 cents per lb, with an extra 5 cents for electrolytic.

QUICKSILVER.—The price has risen from £18. 10s. to £19. 15s. per flask of 75 lb. In the United States the quotation is $80 per flask.

PLATINUM.—290s. per oz.

SILVER.—The price has been firm during the past month, with a tendency to rise slowly and steadily. The latest quotation 37½d. per oz. standard.

No quotation is given for aluminium, antimony, bismuth, cadmium, or for any ore or concentrate.

PRICES OF CHEMICALS. February 10.

Owing to the war, buyers outside the controlled firms have a difficulty in securing supplies of many chemicals, and the prices they pay are often much higher than those quoted below.

		£	s.	d.
Acetic Acid, 40%	per cwt.	2	5	0
,, 60%	,,	3	0	0
,, Glacial	,,	6	15	0
Alum	per ton	14	0	0
Alumina, Sulphate of	,,	18	10	0
Ammonia, Anhydrous	per lb.		1	9
,, 0·880 solution	per ton	32	10	0
,, Chloride of, grey	per cwt.	1	18	0
,, ,, ,, pure	,,	3	10	0
,, Nitrate of	per ton	65	0	0
,, Phosphate of	,,	85	0	0
,, Sulphate of	,,	18	10	0
Arsenic, White	,,	50	0	0
Barium Chloride	,,	30	0	0
,, Carbonate	,,	9	0	0
,, Sulphate	,,	5	10	0
Bleaching Powder, 35% Cl.	,,	29	0	0
Borax	,,	33	0	0
Carbolic Acid, 60% Crude	per gal.		3	6
China Clay	per ton	1	10	0
Copper, Sulphate of	,,	65	0	0
Cyanide of Potassium, 98%	per lb.		1	0
,, ,, Sodium, 100%	,,			10
Hydrofluoric Acid	,,			6
Iodine	,,		14	0
Iron, Sulphate of	per ton	4	15	0
Lead, Acetate of, white	,,	85	0	0
,, Nitrate of	,,	65	0	0
,, Oxide of, Litharge	,,	42	0	0
,, White	,,	47	0	0
Magnesite, Calcined	,,	15	0	0
Magnesium Sulphate	,,	10	10	0
Oxalic Acid	per lb.		1	7
Phosphoric Acid	,,			10
Potassium Bichromate	,,		1	4
,, Carbonate	per ton	115	0	0
,, Chlorate	per lb.		2	4
,, Chloride 80%	per ton	60	0	0
,, Hydrate, (Caustic) 90%	,,	300	0	0
,, Nitrate	,,	75	0	0
,, Permanganate	per lb.		12	6
,, Prussiate, Yellow (Ferricyanide)	,,		4	0
,, Sulphate, 90%	per ton	60	0	0
Sodium Metal	per lb		1	3
,, Acetate	per ton	70	0	0
,, Bicarbonate	,,	7	5	0
,, Carbonate (Soda Ash)	,,	7	0	0
,, ,, (Crystals)	,,	3	5	0
,, Hydrate, 76%	,,	22	0	0
,, Hyposulphite	,,	13	0	0
,, Nitrate, 95%	,,	21	0	0
,, Phosphate	,,	29	0	0
,, Silicate	,,	7	0	0
,, Sulphate (Salt-cake)	,,	2	2	6
,, ,, (Glauber's Salts)	,,	3	10	0
,, Sulphide	,,	22	0	0
Sulphur, Roll	,,	22	0	0
,, Flowers	,,	22	0	0
Sulphuric Acid, non-arsenical 140°T.	,,	4	5	0
,, non-arsenical 95%	,,	7	0	0
Superphosphate of Lime, 18%	,,	5	10	0
Tin Crystals	per lb.		1	4
Zinc Chloride, solution 100°T.	per ton	25	0	0
Zinc Sulphate	,,	25	0	0

STATISTICS.

Production of Gold in the Transvaal.

	Rand	Elsewhere	Total	Value
	Oz.	Oz.	Oz.	£
Year 1912	8,753,563	370,731	9,124,299	38,757,560
Year 1913	8,430,998	363,826	8,794,824	37,358,040
Year 1914	8,033,567	344,570	8,378,139	35,588,075
Year 1915	8,772,919	320,752	9,073,671	38,627,461
January 1916	759,852	27,615	787,467	3,344,948
February	727,346	26,248	753,594	3,201,063
March	768,714	27,975	796,689	3,384,121
April	728,399	26,273	754,672	3,205,643
May	751,198	26,483	777,681	3,303,377
June	735,194	26,570	761,764	3,235,767
July	733,485	27,602	761,487	3,232,891
August	752,940	28,210	781,150	3,318,116
September	744,881	26,686	771,567	3,277,408
October	764,489	27,850	792,339	3,365,642
November	756,370	26,696	783,066	3,326,253
December	748,491	25,971	774,462	3,289,705
Year 1916	8,971,359	324,179	9,295,538	39,484,934
January 1917				

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
January 31, 1916	209,835	9,228	802	219,865
February 29	209,426	9,468	970	219,864
March 31	203,575	9,588	917	214,080
April 30	199,936	9,827	938	210,701
May 31	194,765	9,811	1,459	206,035
June 30	192,809	9,859	2,105	204,773
July 31	192,130	9,932	3,339	205,401
August 31	194,112	10,086	5,146	209,344
September 30	197,734	10,239	6,527	214,500
October 31	199,330	10,907	6,358	216,595
November 30	196,132	11,118	5,928	213,178
December 31	191,547	11,487	5,194	208,228

Cost and Profit on the Rand.

Compiled from official statistics published by the Transvaal Chamber of Mines. The profit available for dividends during 1915 was 63% of the working profit.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
Year 1912	25,486,361	29 2	19 3	9 11	12,678,095
Year 1913	25,628,432	27 9	17 11	9 6	12,189,105
Year 1914	25,701,954	26 6	17 1	9 0	11,553,697
Year 1915	28,314,539	26 3	17 5	8 5	11,931,062
January 1916	2,449,518	26 1	17 10	7 10	962,120
February	2,297,276	26 8	18 4	8 0	924,310
March	2,455,019	26 5	18 1	8 0	979,234
April	2,291,231	26 10	18 2	8 4	951,247
May	2,382,298	26 7	18 2	8 2	977,263
June	2,296,520	27 0	18 3	8 6	977,681
July	2,370,244	26 1	17 10	8 0	949,606
August	2,423,669	26 3	17 10	8 1	976,125
September	2,367,793	26 6	18 0	8 3	972,704
October	2,453,437	26 4	17 10	8 2	1,001,843
November	2,389,056	26 9	18 2	8 2	980,387

Production of Gold in Rhodesia and West Africa.

	Rhodesia.		West Africa.	
	1915	1916	1915	1916
	£	£	£	£
January	293,133	318,586	143,649	140,579
February	286,879	313,769	144,034	137,739
March	299,686	335,368	153,770	150,987
April	315,541	339,386	149,978	135,976
May	318,898	323,783	142,123	132,976
June	322,473	333,070	135,289	127,107
July	336,565	322,365	140,290	128,574
August	344,493	338,001	139,364	125,143
September	321,085	322,035	135,744	127,138
October	339,967	325,608	141,771	132,577
November	313,160	317,135	122,138	130,101
December	331,376	306,205	158,323	146,409
Total	3,823,166	3,895,311	1,706,473	1,615,306

Western Australian Gold Statistics.

	Reported for Export oz.	Delivered to Mint oz.	Total oz.	Total value £
January 1916	1,861	92,124	93,985	399,220
February	2,832	65,138	67,970	288,717
March	5,600	88,393	93,993	399,255
April	2,926	87,601	90,527	384,532
May	577	83,301	83,878	356,289
June	2,070	92,612	94,682	402,181
July	912	91,725	92,637	393,495
August	*	89,522	*	*
September	*	85,978	*	*
October	*	82,732	*	*
November	*	87,322	*	*
December	*	88,205	*	*
January 1917	*	83,962	*	*

* By direction of the Federal Government the export figures will not be published until further notice.

Australian Gold Returns.

	Victoria.		Queensland.		New South Wales
	1915	1916	1915	1916	1916
	£	£	£	£	£
January	69,900	89,900	43,770	66,700	39,000
February	122,300	76,500	85,850	79,050	30,000
March	142,800	103,600	98,550	76,920	36,000
April	109,300	60,000	97,320	83,300	63,000
May	102,900	119,500	130,470	116,230	19,000
June	134,200	86,000	90,500	72,200	18,000
July	154,800	100,600	88,830	85,400	23,000
August	80,300	66,800	93,050	86,000	24,000
September	138,900	115,100	79,470	65,450	32,000
October	111,700	81,400	91,800	74,800	32,000
November	115,300	94,000	77,780	60,300	31,000
December	115,400	96,600	81,170	73,550	111,000
Total	1,397,800	1,090,000	1,078,560	940,500	459,000

Production of Gold in India.

	1914	1915	1916	1917
	£	£	£	£
January	193,140	201,255	192,150	190,047
February	185,508	195,970	183,264	...
March	191,853	194,350	186,475	...
April	189,197	196,747	192,208	...
May	193,031	199,786	193,604	...
June	192,224	197,447	192,469	...
July	195,137	197,056	191,404	...
August	196,560	197,984	192,784	...
September	195,843	195,952	192,330	...
October	198,191	195,531	191,502	...
November	197,699	192,714	192,298	...
December	211,911	204,590	205,164	...
Total	2,340,259	2,366,457	2,299,568	190,047

Daily London Metal Prices

Copper, Lead, Zinc, Tin, in £ per long ton. Silver in pence per standard ounce.

	Copper, Standard	Copper, Electrolytic	Lead	Zinc	Tin, Standard	Silver
Jan.	£ s. d.	£	£ s. d	£ s. d.	£ s. d	d.
11	130 0 0	141	30 10 0	49 5 0	182 15 0	36 1/8
12	130 0 0	141	30 10 0	45 10 0	184 5 0	36
15	130 0 0	141	30 10 0	45 10 0	186 0 0	36
16	130 0 0	141	30 10 0	47 0 0	187 5 0	36
17	130 0 0	141	30 10 0	47 0 0	187 10 0	36 3/8
18	130 0 0	141	30 10 0	51 0 0	188 5 0	36 5/8
19	130 0 0	141	30 10 0	51 10 0	189 5 0	36 [illegible]
22	130 0 0	141	30 10 0	52 0 0	190 10 0	37 1/4
23	130 0 0	141	30 10 0	52 0 0	191 0 0	37 3/16
24	130 0 0	141	30 10 0	52 10 0	189 5 0	37 3/16
25	132 0 0	143	30 10 0	52 10 0	188 15 0	37 3/16
26	132 0 0	143	30 10 0	52 15 0	190 0 0	37 3/16
29	132 0 0	143	30 10 0	53 10 0	191 10 0	37 1/4
30	132 0 0	143	30 10 0	53 10 0	192 15 0	37 5/16
31	134 0 0	145	30 10 0	53 10 0	193 0 0	37 5/16
Feb.						
1	134 0 0	145	30 10 0	53 15 0	195 5 0	37 5/16
2	134 0 0	145	30 10 0	53 15 0	199 5 0	37 5/16
5	134 0 0	145	30 10 0	53 15 0	200 15 0	37 3/8
6	136 0 0	145	30 10 0	54 10 0	202 10 0	37 7/16
7	137 0 0	146	30 10 0	55 5 0	201 0 0	37 1/2
8	137 0 0	146	30 10 0	55 5 0	200 15 0	37 9/16
9	138 0 0	147	30 10 0	56 0 0	200 5 0	37 5/8

* No quotations published.

Imports of Ores and Metals into United Kingdom.

These figures do not include Government imports.

Long tons.

	Dec. 1916	Year 1916	Jan. 1917
	Tons	Tons	Tons
Iron Ore	400,753	6,905,936	511,804
Copper Ore	3,386	34,492	1,949
,, Matte and Precipitate	2,178	43,839	2,091
,, Metal	9,076	111,412	7,981
Copper and Iron Pyrite	70,750	951,206	92,000
Tin Concentrate	1,849	33,912	1,497
,, Metal	1,632	33,646	2,213
Manganese Ore	19,905	439,509	32,047
Lead, Pig and Sheet	19,024	157,985	11,929
Zinc (spelter)	5,519	53,324	6,938
	lb.	lb.	lb.
Quicksilver	1,800	2,556,214	47,044

Stocks of Copper.

Reported by Henry R. Merton & Co. Ld. Long tons.

	Nov. 30, 1916	Dec. 31, 1916	Jan. 31, 1917
	Tons	Not Published.	Not Published.
Standard Copper in England	520		
Fine Copper in England	4,958		
,, ,, Havre	2,123		
,, ,, Afloat from Chile	200		
,, ,, ,, from Australia	4,000		
Total Visible Supply	11,801		
Fine Copper in Rotterdam	1,150		
,, ,, Hamburg	2,867*		
,, ,, Bremen	1,106*		

* As on July 31, 1914, but presumably present stock nil.

Exports of Copper from United States

Reported by United States Customs.

1916	Long tons	1916	Long tons	1917	Long tons
January	21,863	July	35,048	January	25,540
February	20,548	August	34,700	February	—
March	24,006	September	28,572	March	—
April	19,980	October	32,712	April	—
May	14,700	November	21,433	May	—
June	38,277	December	21,438	June	—
		Total 1916	313,277	Total 1917	25,540

Stocks of Tin.

Reported by A. Strauss & Co Long tons.

	Nov. 30, 1916	Dec. 31, 1916	Jan. 31, 1917
	Tons	Tons	Tons
Straits and Australian, Spot	2,014	1,990	1,659
Ditto, Landing and in Transit	1,648	750	835
Other Standard, Spot and Landing	1,048	1,550	1,252
Straits, Afloat	2,282	4,177	4,080
Australian, Afloat	250	330	370
Banca, on Warrants	—	—	—
Ditto, Afloat	3,934	2,578	1,955
Billiton, Spot	—	—	—
Ditto, Afloat	792	533	473
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	673	968	745
Afloat for United States	6,260	4,698	4,517
Stock in America	2,850	3,511	4,622
Total Stock	21,751	21,085	18,508

Shipments and Imports of Tin

Reported by A. Strauss & Co. Long tons.

	Year 1915	Dec. 1916	Total, 1916	Jan. 1917
	Tons	Tons	Tons	Tons
Shipments from:				
Straits to U.K.	23,330	2,870	27,157	1,905
Straits to America	31,565	1,265	25,943	2,165
Straits to Continent	11,024	623	8,487	745
Australia to U.K.	2,481	200	2,537	239
U.K., Holland, and Continent to America	14,967	1,025	14,863	1,550
Imports of China Tin into U.K. and America	3,012	15	1,305	—
Imports of Bolivian Tin into Europe	22,591	629	15,116	527

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note. These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1912	1913	1914	1915	1916
	Tons	Tons	Tons	Tons	Tons
January	204	466	485	417	531
February	240	427	469	358	528
March	247	510	502	418	547
April	141	430	482	444	486
May	144	360	480	357	536
June	121	321	460	373	510
July	140	357	432	455	506
August	201	406	228	438	498
September	196	422	289	442	535
October	256	480	272	511	584
November	340	446	283	467	679
December	310	478	326	533	654
Total	2,540	5,103	4,708	5,213	6,594

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters.
Long Tons.

	1913	1914	1915	1916	1917
	Tons	Tons	Tons	Tons	Tons
January	4,121	4,983	4,395	4,316	3,558
February	3,823	3,555	3,780	3,372	...
March	3,562	3,839	3,653	3,696	...
April	4,066	4,087	3,619	3,177	...
May	4,319	4,135	3,823	3,729	...
June	3,993	4,303	4,048	3,435	...
July	4,245	4,582	3,544	3,517	...
August	4,620	3,591	4,046	3,732	...
September	4,379	3,623	3,932	3,636	...
October	4,409	3,908	3,797	3,681	...
November	3,976	4,085	4,059	3,635	...
December	4,614	4,351	4,071	3,945	...
	50,127	49,042	46,767	43,871	3,558

Sale of Tin Concentrate at Redruth Ticketings.

	Long tons	Value	Average
Year 1915	4,918	£448,362	£90 14 6
July 3, 1916	179	£17,477	£97 12 10
July 17	186½	£17,114	£91 15 4
July 31	172¼	£16,172	£93 17 8
August 14	166	£15,955	£96 2 4
August 28	180¼	£17,345	£96 4 8
September 11	184	£17,113	£93 0 2
September 25	166½	£15,980	£95 19 7
October 9	197	£19,443	£98 13 11
October 23	170	£17,167	£100 19 9
November 8	194½	£19,701	£101 5 10
November 20	172	£18,044	£104 18 2
December 4	160½	£16,588	£105 4 6
December 18	186¼	*	*
Total, 1916	4,668	£478,194	—
January 2, 1917	176	*	*
January 15	160¾	£16,681	£103 15 5
January 29	152	£16,095	£105 17 10

* Prices not published.

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	Feb. 5, 1916 £ s. d.	Feb. 5, 1917 £ s. d.
RAND:		
Bantjes	11 3	7 6
Brakpan	3 18 9	4 18 0
Central Mining (£8)	6 11 3	6 10 0
Cinderella	6 3	4 9
City & Suburban (£4)	2 0 0	1 19 6
City Deep	3 18 3	4 3 0
Consolidated Gold Fields	1 10 0	1 8 0
Consolidated Langlaagte	1 17 6	1 5 0
Consolidated Main Reef	1 0 0	17 3
Consolidated Mines Selection (10s).	15 0	1 0 9
Crown Mines (10s.)	3 3 9	2 18 9
Daggafontein	11 9	12 9
D. Roodepoort Deep	15 6	11 3
East Rand Proprietary	1 0 6	10 9
Ferreira Deep	1 15 0	1 3 9
Geduld	1 17 6	2 1 6
Geldenhuis Deep	1 1 9	1 3 9
Gov't Gold Mining Areas	1 11 0	2 15 6
Heriot	2 10 0	2 7 6
Jupiter	8 6	7 6
Kleinfontein	1 10 0	1 3 0
Knight Central	16 9	9 3
Knight's Deep	1 5 0	1 2 6
Langlaagte Estate	1 0 6	17 6
Luipaard's Vlei	9 0	8 3
Main Reef West	10 6	4 0
Meyer & Charlton	6 1 3	5 11 3
Modderfontein (£4)	16 0 0	19 5 0
Modderfontein B	6 0 0	7 11 3
Modder Deep	6 0 0	7 0 0
Nourse	17 6	1 1 3
Rand Mines (5s.)	4 4 6	3 11 3
Rand Selection Corporation	2 16 3	3 10 6
Randfontein Central	10 0	12 0
Robinson (£5)	1 6 3	18 9
Robinson Deep	1 3 0	1 13 9
Rose Deep	1 10 0	1 0 6
Simmer & Jack	9 6	7 0
Simmer Deep	3 6	4 0
Springs	2 2 6	2 16 3
Van Ryn	2 5 0	1 18 0
Van Ryn Deep	5 3 0	3 7 0
Village Deep	1 18 9	1 8 9
Village Main Reef	19 6	16 3
Witwatersrand (Knight's)	3 0 0	2 13 9
Witwatersrand Deep	1 8 0	1 0 0
Wolhuter	10 0	9 9
OTHER TRANSVAAL GOLD MINES:		
Glynn's Lydenburg	10 0	16 3
Sheba (5s.)	2 0	1 3
Transvaal Gold Mining Estates	1 5 0	1 1 3
DIAMONDS IN SOUTH AFRICA:		
De Beers Deferred (£2 10s.)	11 5 0	13 7 6
Jagersfontein	3 2 6	4 7 6
Premier Defer'd (2s. 6d.)	5 0 0	7 10 0
RHODESIA:		
Cam & Motor	12 6	9 9
Chartered British South Africa	11 0	12 0
Eldorado	10 9	9 0
Enterprise	4 6	5 0
Falcon	9 0	15 0
Giant	6 0	6 6
Globe & Phœnix (5s.)	1 7 0	1 12 0
Lonely Reef	1 3 9	1 8 6
Shamva	1 15 0	1 1 3
Wanderer (3s.)	1 6	1 3
Willoughby's (10s.)	5 0	4 3
WEST AFRICA:		
Abbontiakoon (10s.)	8 0	5 0
Abosso	10 3	8 0
Ashanti (4s.)	18 9	18 6
Prestea Block A	8 6	6 0
Taquah	17 9	17 0
WEST AUSTRALIA:		
Associated Gold Mines	5 3	4 0
Associated Northern Blocks	4 9	3 0
Bullfinch	5 6	1 9
Golden Horse-Shoe (£5)	1 17 6	1 13 9
Great Boulder Proprietary (2s.)	15 0	11 3
Great Boulder Perseverance	1 0	1 0
Great Fingall (10s).	1 9	1 0
Ivanhoe (£5)	2 4 6	2 0 0
Kalgurli	15 0	8 6
Sons of Gwalia	15 6	13 9

GOLD, SILVER, *cont.*	Feb. 5. 1916 £ s. d.	Feb. 5 1917 £ s. d.
OTHERS IN AUSTRALASIA:		
Mount Boppy, New South Wales	14 6	7 0
Talisman, New Zealand	15 0	7 6
Waihi, New Zealand	1 15 6	1 13 6
Waihi Grand Junction, New Z'lnd	18 9	15 9
AMERICA:		
Alaska Treadwell (£5), Alaska	7 2 6	2 10 0
Buena Tierra, Mexico	13 9	8 0
Camp Bird, Colorado	7 6	5 6
Canadian Mining, Ontario	11 0	14 9
Casey Cobalt, Ontario	5 0	6 0
El Oro, Mexico	8 9	7 0
Esperanza, Mexico	10 3	8 0
Frontino & Bolivia, Colombia	9 0	12 9
Le Roi No. 2 (£5), British Columbia	12 6	10 0
Mexico Mines of El Oro, Mexico	3 17 6	4 7 6
Oroville Dredging, California	14 6	15 0
Plymouth Consolidated, California	18 0	1 1 3
St. John del Rey, Brazil	15 0	15 9
Santa Gertrudis, Mexico	10 0	8 3
Tomboy, Colorado	1 2 0	19 6
RUSSIA:		
Lena Goldfields	1 10 0	2 5 0
Orsk Priority	15 0	1 1 3
INDIA:		
Champion Reef (2s. 6d.)	8 6	6 0
Mysore (10s.)	4 0 6	3 3 9
Nundydroog (10s.)	1 6 6	1 5 0
Ooregum (10s.)	1 3 9	19 6

COPPER:

Anaconda (£10), Montana	18 0 0	17 5 0
Arizona Copper (5s.), Arizona	1 11 6	2 2 6
Cape Copper (£2), Cape Province	2 5 0	4 0 0
Chillagoe (10s.), Queensland	6	3
Cordoba (5s.), Spain	3 6	4 0
Great Cobar (£5), N.S.W.	2 6	2 0
Hampden Cloncurry, Queensland	1 13 6	1 13 9
Kyshtim, Russia	1 15 6	2 12 0
Messina (5s.), Transvaal	10 6	10 0
Mount Elliott (£5), Queensland	2 10 0	5 5 0
Mount Lyell, Tasmania	1 6 0	1 5 0
Mount Morgan, Queensland	1 18 0	1 11 9
Rio Tinto (£5), Spain	57 10 0	61 15 0
Sissert, Russia	1 0 0	1 7 6
Spassky, Russia	1 16 3	1 17 6
Tanalyk, Russia	1 15 0	2 7 6
Tanganyika, Congo and Rhodesia	1 12 6	2 8 9

LEAD-ZINC:

BROKEN HILL:		
Amalgamated Zinc	1 8 0	1 10 6
British Broken Hill	1 2 6	1 8 0
Broken Hill Proprietary (8s.)	2 10 0	2 6 6
Broken Hill Block 10 (£10)	16 3	1 0 0
Broken Hill North	2 4 0	2 6 6
Broken Hill South	6 17 6	8 2 6
Sulphide Corporation (15s.)	15 0	1 5 0
Zinc Corporation (10s.)	12 9	14 6
ASIA:		
Burma Corporation	1 13 9	3 16 3
Irtysh Corporation	1 14 6	2 5 6
Russian Mining	15 0	1 1 6
Russo-Asiatic	4 16 3	5 10 6

TIN:

Aramayo Francke, Bolivia	1 6 3	1 10 0
Bisichi, Nigeria	6 0	11 0
Briseis, Tasmania	4 9	4 6
Dolcoath, Cornwall	6 6	9 9
East Pool, Cornwall	12 0	1 10 0
Ex-Lands Nigeria (2s.), Nigeria	1 6	1 6
Geevor (10s.) Nigeria	—	10 3
Gopeng, Malay	1 8 9	1 10 0
Ipoh Dredging, Malay	15 6	13 9
Malayan Tin Dredging, Malay	1 16 3	1 17 6
Mongu (10s.), Nigeria	8 9	9 6
Naraguta, Nigeria	15 0	12 6
N. N. Bauchi Pref. (10s.), Nigeria	4 6	7 9
Pahang Consolidated (5s.), Malay	9 0	9 6
Rayfield, Nigeria	3 9	7 3
Renong Dredging, Siam	1 11 3	2 5 0
Ropp (4s.), Nigeria	15 6	17 6
Siamese Tin, Siam	2 16 3	2 7 6
South Crofty (5s.), Cornwall	8 6	15 0
Tekka, Malay	2 15 0	3 0 0
Tekka-Taiping, Malay	2 3 9	3 0 0
Tronoh, Malay	1 15 0	1 7 0

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also reviews of new books, and abstracts of the yearly reports of mining companies.

ELECTROLYTIC ZINC AT TRAIL.

Mr. T. A. Rickard continues his series of articles on British Columbian mining and metallurgy. In the issue of the *Mining and Scientific Press* for December 23 and 30, he gives details of the Trail smelter near Rossland, British Columbia, operated by the Consolidated Mining and Smelting Co. of Canada. As our readers are aware, this company was formed to acquire the War Eagle and Centre Star gold-copper mines at Rossland and the St. Eugene silver-lead mine near Cranbrook; later, the Le Roi property adjoining the War Eagle and Centre Star was purchased, and also the Sullivan zinc-lead mine in East Kootenay. The Trail smelter comprises lead and copper blast-furnaces, and electrolytic refineries for copper and lead. The novelty that attracts attention to the Trail smelter at present is the recent adoption of the electrolytic process for extracting zinc from the Sullivan ore. This ore occurs in two zones, one higher in zinc than the other. The "zinc" ore averages 13·8% lead, 22·7% zinc, 24% iron, 23·7% sulphur, 3·7 oz. silver, and a trace of gold; this is now treated electrolytically. The ore lower in zinc is called "lead" ore and averages 14% lead; this is sent to the lead smelters. The ore is dense and fine-grained, and impossible to dress by water-concentration; we have not heard what result is given bv selective flotation.

At the time of Mr. Rickard's visit in August last, the procedure with regard to the zinc ore was as follows: The ore is dry-ground in ball-mills so that 90% will pass 150 mesh, and sent to Wedge roasters. The temperature of the furnace is kept within bounds, at about 1,200° F., in order that there shall be no agglomeration or formation of zinc ferrite, The roasted product contains 3 to 5% of sulphur, of which half exists as sulphide and the other half as sulphate. The fume from the roaster is caught in Cottrell apparatus and is sent, along with the roasted material, to the leaching plant. The material, after preliminary damping by water-spray, is delivered into a launder in which a 4% solution of sulphuric acid flows. The acid pulp from the launder goes to a Dorr classifier. The coarse portion here separated is washed and discarded. As it contains much lead, it is delivered to the lead smelter. The slime overflow is pumped to a Brown agitator, otherwise Pachuca vat, where it is agitated for 10 to 15 minutes. The free acid is used-up in the agitation. The overflow from the vat goes to two Dorr thickeners in series, the overflow from the second of which goes to the electrolytic cells. The underflow from the thickeners goes to Dorr agitators, in which it is mixed with fresh acid to remove any undissolved zinc. The solution is removed by a system of counter-current decantation, and is delivered for re-use to the first classifier. The washed slime is delivered to a settling pond for some subsequent treatment for lead content. The air-agitation in the Pachuca vat oxidizes the ferrous iron to ferric, the iron thus been eliminated. The ultimate clear solution before going to the electrolytic cells passes through a Hardinge mill loaded with limestone so that any remaining iron shall be removed, and the solution neutralized. It is also passed through a revolving cylinder containing pieces of zinc weighing 1 lb. each, with the object of removing copper and cadmium. Finally the solution goes through canvas filters. This plant handles 700 tons of solution per day.

Since Mr. Rickard's visit another unit has been erected, treating 1,800 tons of solution per day. Some modifications in arrangement have been made. The roasted ore is mixed with water containing 6% free acid and is then pumped into the first of an "acid" series of Pachucas, each 10 ft. in diameter by 30 ft. high. The overflow from the first goes to a second Pachuca, then to a third, and a fourth, in series, finally overflowing to four Dorr classifiers. Here the coarser particles are washed and discharged, while the slime-overflow goes to six 32 ft. Dorr thickeners for counter-current washing. The overflow from these thickeners is air-lifted to the first of four "neutralizing" Pachucas, where high-grade roasted ore is added to neutralize the solution thoroughly and to coagulate any slime. If necessary, a small quantity of ground limestone is added at the last Pachuca in order to hasten the settling of slime. The overflow from the last Pachuca goes direct to three 32 ft. Dorr thickeners, the overflow from which passes to two Kelly presses, by which it is thoroughly clarified. The filtrate is pnmped to two 10 by 30 ft. Pachucas loaded with granulated zinc, which serves to precipitate the copper and cadmium. The overflow goes to vacuum filters that collect this copper and cadmium, leaving a filtrate that is fit to be an electrolyte. The underflow of the neutral thickeners is pumped to the first member of the first, or "acid," series of Pachucas.

In the electrolytic deposition plant, the anodes are of lead and the cathodes of aluminium. When a new lead anode is put in, it becomes coated with manganese dioxide, which is precipitated from the solution. The manganese is an orginal constituent of the ore. One effect of the coating is to render the lead insoluble. Another is to oxidize such iron as remains in the solution, changing it to the ferric state and thus causing its precipitation. The oxygen derived from decomposition of the zinc sulphate serves to re-oxidize the manganese. The employment of this manganese suggests reference to the work of Andrew Gordon French, a Scottish metallurgist, at one time with the Sheffield Smelting Co., and more recently until his death in 1914 in British Columbia. In our issue of September 1912 we gave an outline of his process for treating zinc-lead sulphides. His process is similar to that established at Trail, except that he added bisulphate of soda at the end of the roasting operation so as to convert the oxide to sulphate. Presumably the bisulphate constituted Mr. French's most convenient source of supply of sulphuric acid. At Trail, however, they manufacture their own acid and the bisulphate suggestion is therefore not of interest. Mr. French also mentioned the use of manganese dioxide covering for the anode, but as this is precipitated from the solution any way, and came from the original ore, the idea could hardly be patentable. The Consolidated Mining & Smelting Co. examined the French process, but negotiations were broken off for some reason never explained.

Mr. Rickard gives some details of the efficiency of the extraction. This is comparatively low, but is continually improving. As regards cost, the company generates its own current hydro-electrically, and though no figures are available we can suppose that the charge for current will be at a minimum. The fact that electrolytic refining of lead is possible indicates a very low cost for current.

MANGANESE DEPOSITS IN RUSSIA.

In our issue of June last we quoted particulars of the Brazilian manganese deposits, taken from a paper written by E. C. Harder on the manganese ores of Russía, India, Brazil, and Chile, and published in the May *Bulletin* of the American Institute of Mining Engineers. On this occasion we give further extracts from this paper, dealing with the Russian deposits. We quote also from the contribution to the discussion on the paper by Herbert K. Scott, which appears in the December *Bulletin*. We take particular pleasure in giving this quotation from Mr. Scott, as he is the leading English authority on the commercial mining of manganese ores.

Mr. Harder mentions that the manganese ores mined in Russia have come largely from the Tchiatouri deposits. Small amounts have come from the Nikopol region in southern Russia north of the Black Sea and from the central part of the Urals.

The Tchiatouri deposits, in the province of Kutais on the southern slope of the Caucasus, are reached by a 21-mile narrow-gauge spur from the main line of the Trans-Caucasian railway, which runs from Poti and Batum on the Black Sea to Baku on the Caspian. Most of the ore is transported in normal times by railroad to Poti or Batum and thence by steamers through the Dardanelles. The Tchiatouri deposits are said to have been discovered in 1879, but the first shipments were made in 1879.

The rocks of the region are Cretaceous and Tertiary sediments, showing great regularity of bedding and having a slight dip of 2½° to the northeast. At the base are Cretaceous chalk and shale, and these are overlain by Oligocene and Miocene sandstone, shale, and chalk. The ores are clearly of sedimentary origin. They occur at the base of the Eocene, in a horizontal bed with a slight northeasterly dip, and are interlayered with sediments. Above the ore bed is brown sandstone of Eocene age, and below is Cretaceous chalk. The total area in which mines occur is about 55 sq. miles, of which 22 sq. miles are probably underlain by good ore. The ore bed contains intercalated layers of sandstone, or of loose, friable, calcareous and arenaceous rock, which vary in thickness from a small fraction of an inch to 10 in. or a foot. The average thickness of the entire manganese bed is 6 or 7 ft.; but that of the ore is not much more than about 3 ft. There are, however, no abrupt or extreme variations in thickness. The Tchiatouri deposits are estimated to contain about 110,000,000 tons of manganese ore. (See Mr. Scott's figure quoted later).

The deposit is distinctly stratified and is composed mainly of pyrolusite, though psilomelane and wad occur in places. The ore is concretionary and oolitic, and in many places shows botryoidal surfaces and concentric structure, the concretions and oolites being imbedded in a matrix of soft powdery ore. Oolitic granules of manganese oxide also occur in the sandstone. The ore contains in some places, without sorting or cleaning, from 48 to 52% of metallic manganese; and the average percentage is from 40 to 45%. Concentrates of exceptional purity, prepared by washing and used in chemical industries, contain from 80 to 90% manganese dioxide. As a general rule, the exported ore which has undergone sorting averages about 51 or 52% of manganese. Where the barren material has been thoroughly separated concentrates may carry as high as 61% manganese. Phosphorus averages about 0·16% and silica not above 8%.

The physical characteristics of the Tchiatouri manganese ore are unfavorable in that the proportion of large pieces obtained is small. Much of the ore is quite soft, and grinds to a fine powder during the handling incidental to mining, cleaning, and transportation. The loss of ore during concentration and transport is therefore considerable; and much of the fine ore shipped is considered objectionable by consumers.

The manganese-ore deposits of the Nikopol district occur in the vicinity of Nikopol on the Dnieper river, about 100 miles from its entrance into the Gulf of Odessa. They were first worked in 1886, and have shown a steady and generally increasing production. The deposits are horizontal beds in Oligocene rocks. Glauconitic clay and sand occur in both hanging and foot walls, the latter being usually more sandy. Immediately underneath the Oligocene strata, and not far below the ore bed are granite and gneiss. At one point, near Horodizce, 18 km. north of Nikopol, the manganese bed is separated from the granite and gneiss basement by a bed of clay and sand only about a foot thick. The area underlain by manganese ore is said to be about 20 sq. km. and the beds are said to have an average thickness of from 1 to 1·5 m. The total tonnage of ore available is estimated at about 7,400,000 tons. The ore-bearing layer consists of sandy clay, much stained by manganese, which contains nodules of psilomelane and pyrolusite with concentric or cellular structure. The better class of ore contains about 57% manganese.

Mr. Scott, in his contribution, says that when examining the Caucasian deposits, he endeavored to determine the quantity of ore originally contained in the deposit, and by deduction, the amount remaining for extraction. These calculations were rendered possible by the great extent of the outcrop and the extensive work that had been carried on in the deposit. In making the first estimate, the quantity of manganese ore and associated sterile material in the bed was measured in a large number of places, and the total quantity of ore originally contained in the deposit was calculated equal to 57,000,000 tons. It was found that only about 15% of the mineral contained in the deposit was exported owing to *(a)* the crude pillar-and-stall method of mining, *(b)* the large quantity of gangue associat-

MAP OF THE CAUCASUS, SHOWING POSITIONS OF MANGANESE ORE DEPOSITS.

ed with the ore, (*c*) the friable character of the mineral, (*d*) its low market value, and the exigencies of the purchaser. In recent years, beginning in 1900, and more particularly since 1905, the introduction of long-wall working and the use of associated sandstone for filling, as well as the construction of numerous washing plants, has resulted in a larger proportion of the orebody finding its way to consumers. Already in 1906, workings were being reopened and pillars and poor ore withdrawn which had been hitherto abandoned, so that in all probability a large part of the ore in the old workings will be eventually recovered, although the measure in which this is done will depend upon the market value of the mineral at the time.

With longwall working 90% of the ore can be obtained, but for the purpose of calculation 75% may be estimated as likely to be realized by reason of the amount of crushed ground. Of the ore available, about 50% will be washed, with a loss of 33%, so that the total quantity of ore likely to be extracted from these deposits will be as follows :

Mineral originally in deposit	57,000,000 tons	
25% loss in working	14,250,000 tons	
	42,750,000 tons	
Lump ore 50% of above		21,375,000 tons
Washable ore 50% of above	21,375,000 tons	
Less loss of 33% in treatment	7,125,000 tons	14,250,000 tons
		35,625,000 tons
Quantity excavated to end of 1914		13,500,000 tons
Quantity of ore available for extraction		22,125,000 tons

This figure differs appreciably from that of 110,000,000 tons mentioned by Mr. Harder. Assuming that the value of the ore permits 1,000,000 tons per annum to be marketed after peace is declared, the deposits should be able to furnish that quantity of ore for over 20 years.

In addition to the minerals, pyrolusite, psilomelane, and wad mentioned by Mr. Harder, an appreciable quantity of a dull reddish mineral was mined, which although originally rejected by reason of not being black, was subsequently found to be of better quality than the general run of ore. A complete analysis of some of the first-quality stuff indicated that it was probably manganite ($Mn_2O_3.H_2O$), and as the complete analysis may be of interest, it is given herewith :

	Per Cent.
Silica	3·02
Manganese peroxide	48·02
Manganese monoxide	36·00
Ferric oxide	0·64
Alumina	0·91
Baryta	0·84
Lime	1·05
Magnesia	0·22
Phosphoric acid	0·337
Arsenic acid	nil
Sulphuric acid	0·542
Oxide of copper	0·03
Oxide of lead	nil
Oxide of zinc	trace
Combined water	8·40
	100·009
Manganese (metal)	58·25
Iron (metal)	0·45
Phosphorus	0·147
Sulphur	0·217

Mr. Scott visited the deposits of the Nikopol district in 1907, and found that manganese ore had been proved to exist over a large area. No calculation even reasonably near the truth can, however, be made regarding the quantity of mineral likely to be contained in the area underlain by manganese ore, inasmuch as the outcrops of the ore are limited in extent, and the details of the thickness and composition of the bed over the area have not been obtained on a sufficiently comprehensive scale. Mr. Scott considers that the quantity of mineral available is very large. The totals given by Mr. Harder regarding the area of the deposit and the mineral available, apparently taken from the Beyschlag-Krusch-Vogt treatise, represent, in Mr Scott's opinion, but a fraction of the correct figures, and further do not appear to be in correct relation with each other, for an area of 20 sq. km. underlain by a manganese-ore bed 1 to 1·5 m. in thickness would not give a total quantity of mineral available of 7,500,000 tons. Dr. N. Sokolow, who studied these deposits in 1901, shows the manganese-ore area as exceeding 200 sq. km. in extent, and in one deposit seen by Mr. Scott, with an area of over 50 sq. km. in which many test pits and bore-holes had been made, the quantity of ore available, estimated by a Russian engineer of standing, was many times greater than the total given by Mr. Harder for the whole zone.

Generally, the mineral excavated consists of 20% lumpy and 80% small ore. The establishment of washing plants is general and approximately 50% is lost in treatment.

At one property of which the run of mine ore contained 34% Mn, the whole of the output was washed, giving the following results:

	Per Cent.	
First grade	50·00	Manganese (metal)
	8·00	Silica
	10·00	Moisture
	0·16	Phosphorus
Second grade	40·00	Manganese (metal)
	28·00	Silica
	10·00	Moisture
Tailing	20·00	Manganese (metal)
	38·00	Silica

DREDGING PROBLEMS, RETROSPECTIVE AND PROSPECTIVE.

At the present time dredging problems are attracting special attention in England owing to the publication of Mr. H. D. Griffiths' articles in this Magazine. Last month we quoted a paper by Mr. A. C. Perkins, manager for the Malayan Tin Dredging Co., on Malay conditions. Herewith we give the substance of an article, appearing in the October number of the *Mining and Engineering Review* of Melbourne, written by Mr. F. W. Payne. Mr. Payne is a New Zealander who has done excellent work in his own country, and in the Malay peninsula he has designed the dredges of the Malayan Tin Dredging Company. Mr. Payne does not often go into print, so we quote him with all the more pleasure.

Probably the first mineral dredges were those put to work in New Zealand in the late eighties. At that time a small fleet of dredges was built for the Shotover and Clutha rivers. The first dredge was one built by a Dunedin company to work on the Clutha river, near the township of Alexandra South. Not meeting with immediate success, the dredge was moved 30 miles down the river to just above Roxburgh, where it had a long and chequered career. This dredge was originally equipped with two bucket ladders, one on each side. This arrangement was a failure, owing to first one line of buckets getting into heavy work and then the other, causing the dredge to rock sideways to such an extent as to render satisfactory cleaning up of the river bottom impossible. The pioneer builders were, however, men of resource and prompt action, and they cut the dredge down the centre and formed two separate pontoons, between which they then set one of their bucket ladders to work. This plucky old-time ship had practically the whole of the river to choose from and, as often happens in such cases, she left the richest portions for later venturers.

Before the advent of the dredges, the banks of the Clutha river had been in many places worked for gold to a line as near as possible to water level, and these old workings, with in some cases long water races leading to them, still stand as monuments of what a few men can do when lured on by the stimulus of gold. The location of the early-time dredges was generally determined by the amount of success these old miners had achieved in the river banks or beaches.

The first small fleet of dredges commencing work in the late eighties were not very successful, and on the companies going into liquidation the dredges were bought for trifling sums by small private parties. These men were many of them sailors, and worked the dredges themselves. As the working expenses were low and the only wages to be paid were to themselves, they could afford to work and wait, and their rewards came.

The first dredging ventures were confined to the river beds, and when the dredges began to trace the gold leading into the banks the problem arose as to the disposal of the tailing, and the first tailing elevators were installed. As river flats and high banks were dredged into, these elevators quickly developed into a very important feature of the gold dredges. A dredging venture that failed to strike gold during the first few weeks of its working had small chance of success, as few had sufficient capital behind them to effect more than a start. No doubt there are still large tracts of land in New Zealand that will some day pay handsomely for dredging. The dredges that ultimately work these deposits will of course be far in advance of the machines that were built in the nineties. Prospecting has now become more easy to carry out and has achieved a reliability unheard of in the boom time, and it is safe to say that never again will dredges be built and put to work before the value of the ground has been thoroughly tested.

The chief centre of Australian dredging interest at the present time is in the Federated Malay States and Siam. Tin dredging has achieved a great success in these conntries and under conditions that, from a dredging engineer's point of view, are by no means ideal. The results, however, are the only test worth considering. Dredging in Malay had first, as elsewhere, to overcome prejudice, and also an opinion honestly held by many mining men that it was not feasible to dredge where a limestone bottom existed; especially as the limestone is sometimes in pinnacles, which is not an ideal condition for bucket dredging.

The first dredge of the Malayan Tin Dredging Ltd., the pioneer dredge of Malay, was started with serious misgivings. Mr. A. C. Perkins, of the author's firm of consulting engineers, had boldly declared for bucket-dredging in this company's area, and he remained long enough in Malay after supervising the erection of the first dredge, to see his optimistic views justified. This dredge has now been followed by three others of larger and improved type,

Further up the Kinta Valley the Ipoh Company has a dredge at work which, although hampered financially at the start, has now cleared itself and is paying dividends. The pessimists were loud in their condemnation of this property, and it required a bold man to hold hopeful views concerning it, but the results have vindicated the faith of the few. Almost adjoining the Malayan Company's ground on the opposite side of the railway line is the Kinta Valley Company's area. This ground is practically the same as the Malayan, and as exhaustive boring shows highly satisfactory values, the success of this venture may be taken as assured.

A most important condition to a successful result in a dredging venture is the class of dredge that is put to work on the claim. A peculiarity of bucket-dredging is that variations in design of machinery are required for almost every claim, and thus a dredge cannot be ordered like a reaper and binder or a motor car. Every detail has to be carefully thought out and designed with a view to the particular requirements of the area concerned. Engineers cannot increase the mineral contents of the ground, but they can reduce the working expenses, which effects the same result. The aim of the designer should be to secure the greatest return at the least expense, and whether this is effected by large, expensive dredges or smaller and less imposing machines, the result is equally satisfactory from the point of view of the shareholder, which is the only point of view that has a right to be considered. One important feature of dredge design is simplicity. An old client of the author's who was largely interested in New Zealand dredging used to say that he wanted a dredge with one wheel. This, although impossible, is perhaps as good an ideal as any for the dredge designer to aim for. When complications are introduced he must be satisfied that such complications are justified by reduced expense somewhere, that they will reduce labour or facilitate operation in such a way as to effect a sensible saving of time or fuel or effect a better saving of the mineral.

Losses in recovery should be combated strongly. It should not be overlooked that every cubic yard of material that is lifted has cost the company so much actual cash, and to let mineral go overboard again is equivalent to the action of a shopkeeper who, when emptying the till, would throw away the coppers on account of the trouble incurred in counting them. The dredge designer has, therefore, two requirements to study : (1) save every possible cent in working expenses ; (2) save every possible grain of mineral that comes on board. There is still room for the engineer to exercise his ability and inventive faculties in bringing these two questions nearer to the irreducible minimum. The second problem is definite, as when all the mineral is recovered no more can be done. The first will always be comparative, as with whatever power is used and whatever machinery employed it will always cost something to run. In practice both questions offer good margins for improved methods.

The future of dredging is largely with the engineers. Every sensible advance made by the engineer in the directions indicated brings fresh territory into the range of paying propositions. The opinion is often expressed that the palmy days of dredging are over. This is no doubt true if what is meant are the days when capital could be secured to dredge any likely-looking piece of ground without prospecting it, but in the opinion of those in the best position to be able to judge, real legitimate dredging enterprise is practically only commencing.

POSSIBLE OIL OCCURRENCES IN ENGLAND.

At the meeting of the Institution of Petroleum Technologists held on January 16, W. Forbes-Leslie read a paper on the occurrences of oil in England, and discussing future chances of finding deposits in commercial quantities. The author read a paper recently on the oil-shales of Norfolk, abstracted in our issue of November last ; and a paper was read by W. H. Manfield on the Kimmeridge oil-shales, noted in our issue of March a year ago. In the present paper, Mr Forbes-Leslie records and classifies all the known occurrences of oil in England, as distinct from occurrences of oil-shales, and his list is a great deal longer than the average engineer would imagine. These occurrences can be conveniently divided into three zones. The first of these comprises the area west of Meridian 3 West, and among the occurrences are those at Whitehaven in Cumberland, at Formby on the Lancashire coast, at Ruabon in Denbigh, at Merthyr in Glamorgan, and at Barnstaple in Devonshire. Of these, all but the Formby occurrence would be in Paleozoic rocks.

The second, or middle, zone is of much greater importance than the first, or western. This zone includes occurrences in southeast Lancashire, south Yorkshire, Derbyshire, Nottingham, Stafford, and Shropshire. These are associated with rocks of the Carboniferous system. Three of these occurrences deserve mention. At Southgate colliery near Chesterfield, in the Derbyshire coalfield, an intermittent flow of petroleum mixed with an equal volume of water at the rate of 70 to 100 gallons daily came from the rock at 960 ft. from the surface. A seepage of historic interest occurred at the Riddings colliery at Alfreton, in the same coalfield, for this flow was utilized by Dr. James Young, before he transferred his activities to the development of the Scottish oil-shales. The most important indication of all, however, was provided by a bore-hole at Kelham, near Newark, Nottinghamshire. Here the source of the oil was ascertained to be a coarse porous sandstone 15 ft. thick underlying the Coal Measures, at a depth of 2,452 ft. The pressure was sufficient to force the oil upward against the weight of superincumbent water.

The third, or eastern, zone extends from Filey on the Yorkshire coast through Lincolnshire to western Norfolk and Cambridgeshire. The chief seepages of oil are found at Filey and Pickering in Yorkshire, Brigg in Lincolnshire, King's Lynn in Norfolk, and Ely in Cambridge. These occurrences are associated with the Oolite, and are therefore presumably allied to the oil-shales of the Kimmeridge rocks. The districts in the eastern part of the middle zone and the western part of the eastern zone can be studied together, and can be divided into three sections which correspond to four well-defined folds in the rocks. One of these folds is visible on the surface, one has been determined by bore-hole, and the other two have been deduced from stratigraphical observations. This point indicates Mr. Forbes-Leslie's method of prospecting for oil. His evidence of seepages, as recorded above, goes to prove that oil exists at various places at depth, and that at some spots there must be accumulations. This prospecting cannot be done on the surface, but only by deductions relating to the positions of the buried rocks. This type of investigation has for many years been undertaken by geologists in search of coal. Similar work should be done in connection with oil. The author proceeds to give at some length his reading of the geology at depth in many parts of the country, pointing out where tests by bore-hole might be advantageously made. The principal oil-containing forms in the concealed and visible systematic sectional arrangements of the eastern depression are the Ashover-Sherwood-Kelham anticline, the Castleton-Retford anticline, and the Ouse Valley fold, the last named being the Lynn-Downham anticline.

COPPER, LEAD, AND ZINC SMELTERS IN AMERICA.

Herewith we give particulars, condensed from tables published in the *Engineering and Mining Journal* for January 6, relating to the copper, lead, and zinc smelters in North America. The figures attached indicate roughly the capacity of each works.

COPPER-SMELTING WORKS OF NORTH AMERICA.

Company	Works	No. of Furnaces
American Smelting and Refining	Aguascalientes, Mex.	10
	Perth Amboy, N.J.	1
	Omaha, Neb.	2*
	El Paso, Tex.	6
	Matehuala, S.L.P., Mex.	3
	Hayden, Ariz.	3
	Sasco, Ariz.	2
American Smelters Securities	Garfield, Utah	10
	Tacoma, Wash.	3
	Velardeña, Dgo., Mex.	3
Anaconda Copper, Anaconda, Mont.		11
Anaconda Copper, Great Falls, Mont.		4
Arizona Copper, Clifton, Ariz.		3
Balaklala Consolidated Copper, Coram, Calif.†		4
Compagnie du Boleo, Santa Rosalia, Mex.		8
British Columbia Copper, Greenwood, B.C.		3
Calumet & Arizona Mining, Douglas, Ariz.		3
Canadian Copper, Coppercliff, Ont.		3
Cananea Consolidated Copper, Cananea, Son.		10
Consolidated Arizona Smelting, Humboldt, Ariz.		3
Consolidated Mining & Smelting, Trail, B. C.		5
Copper Queen Consolidated, Douglas, Ariz.		13
Detroit Copper Mining, Morenci, Ariz.		1
Ducktown Sulphur, Copper, Iron, Isabella, Tenn.		2
East Butte Copper Mining, Butte, Mont.		2
Granby Consolidated, Grand Forks, B. C.		8
Granby Consolidated, Anyox, B. C.		4
International Smelting, Tooele, Utah		5
International Smelting, Miami, Ariz.		4
Mammoth Copper Mining, Kennett, Calif.		5
Mason Valley Mines, Thompson, Nev.		2
Mazapil Copper,† Concepcion del Oro, Zac, Mex.		4
Mond Nickel, Coniston, Ont.		3
Mountain Copper, Martinez, Calif.		3
Nevada Consolidated Copper, McGill, Nev.		6
Nichols Copper, Laurel Hill, N. Y.		2
Norfolk Smelting, West Norfolk, Va.		1
Old Dominion Copper, Globe, Ariz.		5
Orford Works, International Nickel, Constable Hook, N. J.		2
Penn Mining, Campo Seco, Calif.		2
Pioneer Smelting,† Corwin, Ariz.		1
Santa Fe Gold and Copper, San Pedro, N. M.		1
Shannon Copper, Clifton, Ariz.		3
Swansea Consolidated, Bouse, Ariz.		1
Tennessee Copper, Copperhill, Tenn.		7
Teziutlan Copper,† Teziutlan, Puebla, Mex.		2
Cia. Metalurgica de Torreon, Coah., Mex.		2
Tyee Copper,† Ladysmith, B. C.		2
U. S. Metals Refining, Chrome, N. J.		2
U. S. Smelting,† Midvale, Utah		7
United Verde Copper, Clarkdale, Ariz.		7
Wanakah Mining,§ Ouray, Colo.		2
Western Sm. & Power,‡ Cooke, Mont.		1

* Converters. † Not in operation. ‡ Under construction. § Plant sold to Ouray Smelting and Refining Co.

ELECTROLYTIC COPPER REFINERIES OF THE UNITED STATES AND CANADA.

Refinery	1916 Capacity, Pounds
Nichols Copper Co., Laurel Hill, N. Y.	450,000,000
Raritan Copper Works, Perth Amboy, N. J.	460,000,000
Baltimore Copper, Canton, Md.	600,000,000
American Smelting & Refining, Perth Amboy, N. J.	240,000,000
United States Metals Refining, Chrome, N. J.	250,000,000
Balbach Smelting & Refining, Newark, N. J.	48,000,000
Anaconda Copper (old plant), Great Falls, Mont.	65,000,000
Anaconda Copper (new plant), Great Falls, Mont.	180,000 000*
Tacoma Smelting Co., Tacoma, Wash.	130,000,000
Calumet & Hecla, Calumet, Mich.	65,000,000
Consolidated Mining & Smelting, Trail, B. C.	*
Totals	2,488,000,000

* New works put in operation in 1916.

ZINC-SMELTING CAPACITY OF THE UNITED STATES.

Works	Number of Retorts at end of 1916
American Spelter Co., Pittsburg, Kan.	896
American Steel & Wire Co., Donora, Penn.	9,120
American Zinc and Chem. Co., Langeloth, Penn.	7,296
American Zinc Co. of Ill. Hillsboro, Ill.	4,864
American Zinc, Lead and Smg. Co., Dearing, Kan.	4,480
American Zinc, Lead and Smg. Co., Caney, Kan.	6,080
Arkansas Zinc and Smelting Corpn. Van Buren, Ark.	2,400
Athletic Min. and Smelting Co., Fort Smith, Ark.	(*h*)
Bartlesville Zinc Co., Bartlesville, Okla.	7,488
Bartlesville Zinc Co., Blackwell, Okla.	8,800
Bartlesville Zinc Co., Collinsville, Olka.	13,440
Chanute Spelter Co., Chanute, Kan.	1,280
Cherokee Smelting Co., Cherokee, Kan.	(*i*)896
Clarksburg Zinc Co., Clarksburg, W. Va.	3,648
Collinsville Zinc Co., Collinsville, Ill.	1,984
Eagle-Pincher Lead Co., Heneryetta, Okla.	3,000
Edgar Zinc Co., Carondelet, Mo.	2,000
Edgar Zinc Co., Cherryvale, Kan.	4,800
Fort Smith Spelter Co., Fort Smith, Ark.	2,560
Granby Mining and Smg. Co., (*j*) Neodesha, Kan.	3,760
Granby Mining and Smg Co., (*j*) E. St. Louis, Ill.	4,864
Grasselli Chemical Co., Clarksburg, W. Va.	5,760
Grasselli Chemical Co., Meadowbrook, W. Va.	8,544
Grasselli Chemical Co., Terre Haute, Ind.	(*h*)
Hegeler Zinc Co., Danville, Ill.	5,400
Henryetta Spelter Co., Henryetta, Okla.	3,000
Illinois Zinc Co., Peru, Ill.	4,640
Iola Zinc Co., Concreto, Kan.	660
Joplin Ore and Spelter Co., Pittsburg, Kan.	(*k*)1,792
J. B. Kirk Gas and Acid Co., (*c*) Iola, Kan.	3,440

Kusa Spelter Co., Kusa, Okla	3,720
La Harpe Spelter Co., Kusa, Okla	4,000
Lanyon Spelter Co., Pittsburg, Kan	448
Robert Lanyon Zinc and Acid, Hillsboro, Ill	3,200
Lanyon-Starr Smelting Co., Bartlesville	3,456
Matthiessen and Hegeler Zinc La Salle, Ill	6,168
Mineral Point Zinc Co., Depue, Ill	9,068
Missouri Zinc Smelting Co., (k) Rich Hill, Mo.	448
National Zinc Co., Bartlesville, Okla	4,970
National Zinc Co., Springfield, Ill	3,800
Nevada Smelting Co., Nevada, Mo	672
New Jersey Zinc Co., of Penn, Palmerton, Penn	7,200
Oklahoma Spelter Co., (k) Kusa, Okla	1,600
Owen Spelter Co., (f) Caney, Kan	1,920
Pittsburg Zinc Co., Pittsburg, Kan	910
Prime Western Spelter Co., Gas City, Kan	4,866
Quinton Spelter Co., Quinton, Okla	1,340
Sandoval Zinc Co., Sandoval, Ill	672
Tulsa Fuel and Manufacturing, Collinsville, Okla	6,232
United States Smelting Co., Altoona, Kan	4,600
United States Smelting Co., Checotah, Okla	4,480
United States Smelting Co., La Harpe, Kan	1,926
United States Zinc Co., (e) Sand Spring, Okla	8,000
United States Zinc Co., Pueblo, Colo	1,984
United States Smelting Corpn., Moundsville, W. Va.	(h)
Weir Smelting Co., Weir, Kan	448
Totals	211,126

(c) Taken over by U. S. Smelting Co. in July 1915. (e) Formerly Tulsa Spelter Co. (f) Operated by American Zinc, Lead and Smelting Co. (h) Under construction. (i) Idle. (j) Subsidiary of American Zinc, Lead and Smelting Co., 1916 (k) Idle latter part of 1916.

American Silver-Lead Smelting Works.

		Furnaces
American Smelting & Refining	Denver	7
	Pueblo	7
	Durango	4
	Leadville	10
	Murray	8
	East Helena	4
	Omaha (†)	2
	Chicago (†)	1
	Perth Amboy (†)	4
Consolidated Kansas City Sm. and Ref., El Paso		6
Bunker Hill & Sullivan, Kellogg, Idaho		*
Selby Smelting and Lead, Selby, California		3
Ohio & Colorado Smelting, Salida, Colo.		4
United States Smelting, Midvale, Utah		7
Needles Smelting, Needles, Cal. (‡)		2
Northport Smelting & Refining, Northport, Wash.		3
Pennsylvania Smelting, Carnegie, Pa.		2
International Smelting, Tooele, Utah		5
Totals, United States		79
American Smelting & Refining	Monterey	10
	Aguascalientes	1
	Chihuahua	7
American Smelters Securities, Velardeña		3
Compania Metalurgica Mexicana, San Luis Potosi		10
Campania Metalurgica de Torreon, Torreon		8
Compania Minera de Penoles, Mapimi (‡)		6
Totals, Mexico		45
Consolidated Mining and Smelting, Trail, B.C.		4

* Plant under construction. † Smelt chiefly refinery between-products. ‡ Not being operated.

CURRENT EFFICIENCY IN ELECTROLYTIC COPPER REFINING.

In *Metallurgical and Chemical Engineering* for January 1, Lawrence Addicks discusses the various causes of inefficiency in electrolytic copper refining. Current efficiency in an electrolytic operation is the ratio between the weight of product obtained per ampere hour and that called for by Faraday's law. It is desirable to obtain as high a current efficiency as may be consistent with the cost of securing it. It is quite possible with care, and without considering the question of labour cost, to obtain a working efficiency on a large scale of 99%. Commercially it is found, however, that about 92% is as high a figure as it is advisable to insist upon, and at some plants 90% or even 88% is considered satisfactory.

The various factors making for inefficiency may be classified as follows:

(1) Current leakage: (a) to ground, (b) through electrolyte, (c) between electrodes; (2) Reaction: (a) deposition of impurities, (b) gassing, (c) valence; (3) Cathode shrinkage: (a) sulphatizing, (b) ferric salts, (c) nodules, etc.

(1a) *Leakage to Ground.*—The insulation resistance of the circuit from the ground may be determined by noting the reading of a high-resistance voltmeter when connected from either switch terminal on the live circuit to the ground by a simple application of Ohm's law. The current flowing through the voltmeter is obtained by dividing its reading by its known resistance; the total resistance in the leakage circuit is obtained by dividing the known line voltage by thfs current; the insulation resistance is found by subtracting the known voltmeter resistance.

It is evident that the resistance found in this way is a measure of the obstacles in the path of the current from the ground back through improper channels to the other leg of the circuit, and that by opening the main circuit at predetermined points and taking repeated measurements a leakage map could be worked out. This, however, should not be necessary, as while the insulation resistance of an electrolytic circuit will always be low—a usual value is five ohms—the actual loss of effective current from this source is a minor matter in any plant where the foundation piers are properly capped with glass plates and tank leaks kept from resulting in sulphate crystals climbing around promiscuously.

If we assume that a circuit has a total resistance of five ohms from one side to the other through the ground, and that the line voltage is 150, this leakage will be only 30 amperes. If the main current is 10,000 amperes, and the leakage uniformly distributed so that it robbed an average of only half the tanks, the percentage loss would be only 0·15%.

(1b) *Leakage through Electrolyte.*—There are three ways of determining the loss of effective current due to improper shunt circuits through the circulation system: by direct measurement, by Ohm's law calculations, and by Faraday's law calculations.

The direct method consists of placing carefully calibrated ammeters at various points in the circuit and comparing their readings, which would be identical except for losses under (a) and (b). Considerable care is required to avoid errors in measurement, as thermoelectric effects may creep into the temporary shunt connections and magnetic errors, due to strong stray field, may distort the meter readings even when the instruments are protected by iron cases. An unprotected portable instrument may even be permanently thrown out of adjustment by exposure of its permanent magnets to the action of the stray field which exists within a couple of feet of a conductor carrying 10,000 amperes. Another method is to open the circuit in the centre and note how many amperes are recorded by the power-house ammeter when full voltage is applied. This is not fair in that the voltage distribution throughout the circuit is not normal. It will generally be found that the tanks at the far end of a circuit receive 3 or 4% less than the switchboard current.

Ohm's law calculations may be made upon the liquid columns of electrolyte, as we know the resistance per cubic inch of the liquor, its physical dimensions, and the voltages operating. Where the voltages are sufficiently low, the lead pipe cannot act as a conductor, as when the current leaves it there must be sufficient voltage to decompose water. When such voltages occur sections of hard rubber or of rubber hose are employed to break the continuity of the metal path. It is also possible to take fall of potential readings along a lead pipe and figure the current flowing therein by Ohm's law and the specific resistance of hard lead.

Thirdly, we know that wherever the current enters the piping system it must deposit Faraday's equivalent of copper. This is of great practical assistance, as while it gives no information regarding the current flowing in the liquid itself, it does bring to daily attention any abnormal participation of the conduit system, and the accumulation of copper trees demands early attention to avoid stopping up the pipes.

The coating of lead sulphate which covers all tank linings and pipes exposed to the action of the electrolyte acts as an insulating paint of much value, as shown by the low efficiencies always obtained in starting up a new installation of bright tanks. A final insulating joint is usually effected where the electrolyte leaves a tank by allowing it to fall freely into the launder without a containing pipe for some inches.

(1c) *Leakage between Electrodes*.—The direct touching of anode and cathode is the most usual cause of poor efficiency. This condition can be brought about by the electrodes being carelessly spaced in the tank, by the curling of starting sheets, by falling of anode scrap, by omission of electrode insulators, by electrodes displaced sideways so as to touch the lead lining of the tank, by treeing of the cathode deposit, by the accumulation of an excessive quantity of slime in the bottom of the tank, or by the careless leaving of tools lying on top of the electrodes.

It is obvious that with the exception of treeing and falling anode scrap these causes may be removed in proportion to the amount of labour and inspection applied. Treeing involves the control of the cathode deposit by the choice of a suitable cathode age for the current density employed, adequate circulation of the electrolyte, and the use of additional agents A cathode deposit starts as a fine frosting, and with a violent circulation this builds up with perfect smoothness. It is not possible to employ even a rapid circulation, however, on account of the consequent stirring up of anode slime, and any mechanical scouring effect is therefore lost. On the other hand, the circulation must be maintained at a rate sufficient to supply copper ions at the cathode as fast as demanded by the current density, or other ions will act as carriers of the current and the deposit will become rough and non-adherent. Even under normal conditions fine needles soon spring out in crystal formation. The moment the cathode surface becomes roughened, the parts nearest the anode offer the path of least resistance to the current and bad soon becomes worse. The function of addition agents is first to round off these needles into blunt nodules, and second to change what is called "cocoa matting" structure to a hard compact deposit. Ordinary lubricating oil possesses some property which effects the first and minute quantities of glue the second.

The falling apart of scrap anodes results from incomplete refining of the blister copper in the anode furnace. As the condition causes an abnormal quantity of scrap and leaks from pierced tank linings as well as low-current efficiency the remedy lies in better furnace treatment.

A short circuit between two electrodes is not as serious as at first appears, because there is a certain resistance due to conductors and contacts in series with each electrode and a number of parallel circuits. For example, if we have thirty pairs of electrodes and the series resistance amounts to one-quarter of the total across the tank, it is evident that a reduction of 75% of the resistance in one of thirty parallel circuits will but make it equal to four normal circuits out of the thirty and not draw any great share of the current. Then the increased current flow heats the conductors and contacts affected, and this increases their resistance. Finally, there is a certain rebate on the voltage side due to the lowered resistance of the tank when it comes to pounds of cathode per kilowatt-hour. In general an economic balance is struck when about 5% of the current is rendered non-effective by local short circuits.

(2a) *Deposition of Impurities*.—In the ordinary depositing tank the current consumed in the direct deposition of impurities is obviously negligible, as appears from the great purity of the cathode; in fact, it is an open question whether any of the traces of impurities found in cathode copper are due to the electrolytic action. Where insoluble or partly soluble anodes are used and higher voltages obtain, this item becomes measurable. An example of the first case is where arsenic is deposited in a "liberator" tank in copper refining, and of the second where iron is deposited in a copper-nickel refinery.

(2b) *Gassing*.—A copper cathode rarely shows up on analysis above 99·95% copper. The metallic impurities may total 0·02%, still leaving some unaccounted-for difference. Part of this is included electrolyte, but after all allowances are made it seems probable that hydrogen is present either as hydride or by occlusion. We know that some addition agents harden the cathode, and that this hardness may be removed by annealing. When all the copper in a liquor is plated out, as in the case of an electrolytic assay, the gassing does not begin and the voltage rise suddenly upon the exhaustion of the copper, but some gassing starts early and the voltage gradually rises. In the same way local conditions at the cathode due to the moderate circulation employed may cause the separation of a certain amount of hydrogen at the cathode in a normally operating cell. It seems probable, therefore, that a small proportion of the current may be diverted into depositing hydrogen instead of copper, and even a minute quantity of hydrogen will account for a measurable current on account of its very low electro-chemical equivalent. For example, 0·03% of hydrogen would take 0·9% of the current. We do not know how much of a source of loss this condition is in straight copper work, but in nickel deposition it may be enormous, free hydrogen appearing in quantity at the cathode.

(2c) *Valence.*—The efficiency is based upon the reaction

$$CuSO_4 + H_2O + \text{current} = Cu + H_2SO_4 + O$$

where copper acts as a divalent metal. It is evident that should the copper in the electrolyte be present in a cuprous salt, copper might be precipitated at an apparent efficiency of 200%. Cuprous salts are undoubtedly formed to a certain extent at the anode, as shown by the cuprous chloride and metallic dust found in the slimes resulting from such a reaction as

$$Cu_2SO_4 = CuSO_4 + Cu.$$

although the latter is partly due to

$$Cu_2O + H_2SO_4 = CuSO_4 + H_2O + Cu.$$

Cuprous sulphate is very unstable or we should gladly use it as the basis of an electrolyte, and it seems very unlikely that an appreciable amount exists at the cathode. The cuprous chloride found in the cathode when excess chlorides are allowed to accumulate in the electrolyte is doubtless due to direct reduction by the cathode as

$$CuCl_2 + Cu = 2CuCl.$$

(3a) *Sulphatizing.*—A certain amount of the deposited copper is re-dissolved by the electrolyte. While copper is not normally soluble in sulphuric acid, the oxygen dissolved in the electrolyte aids in a slow attack.

$$Cu + H_2SO_4 + O = CuSO_4 + H_2O$$

probably expresses the complete reaction. As would be expected the action is particularly marked at the solution line and various expedients, such as painting or changing the solution level, have to be employed in order to prevent the cathode loops cutting through at the solution line. The amount of this chemical action is indicated by the growth in the copper content of the electrolyte after correcting for anode impurities dissolving electrolytically and cuprous oxide in the anode dissolving chemically, and it is found to increase rapidly with increase of temperature of the electrolyte. A fair figure is about 2% of the deposited copper, and if we assume that half of this came from the anodes we have an apparent loss in current efficiency of 1 per cent.

(3b) *Ferric Salts.*—If the anodes are not free from iron, converter anodes, for instance, and the resulting ferrous sulphate is allowed to accumulate in the electrolyte, there is a tendency, increasing with concentration, for this salt to be oxidized at the anode

$$2FeSO_4 + H_2SO_4 + O = Fe_2(SO_4)_3 + H_2O.$$

This is particularly the case in insoluble anode tanks where the ferrous sulphate acts as a depolarizer. This ferric salt is again reduced, either electrically at the cathode

$$Fe_2(SO_4)_3 + 2H = 2FeSO_4 + H_2SO_4$$

or by the anodes and cathodes chemically

$$Fe_2\,(SO_4)_3 + Cu = 2FeSO_4 + CuSO_4.$$

In either case there is a diversion of the current from its normal work and a corresponding loss in current efficiency. Under bad conditions, such as obtained in leaching copper ores, this loss may become very serious, but in straight refining work it should be entirely negligible.

(3c) *Nodules, Etc.*—There is a certain apparent loss in efficiency due to mechanical shrinkage of the cathode from nodules falling into the slimes, chiefly due to inspection work on the tanks. This material is screened out of the slimes later, but is too contaminated to be considered legitimate production. Unless the deposit is rough the amount of this shrinkage will be but a small fraction of 1 per cent.

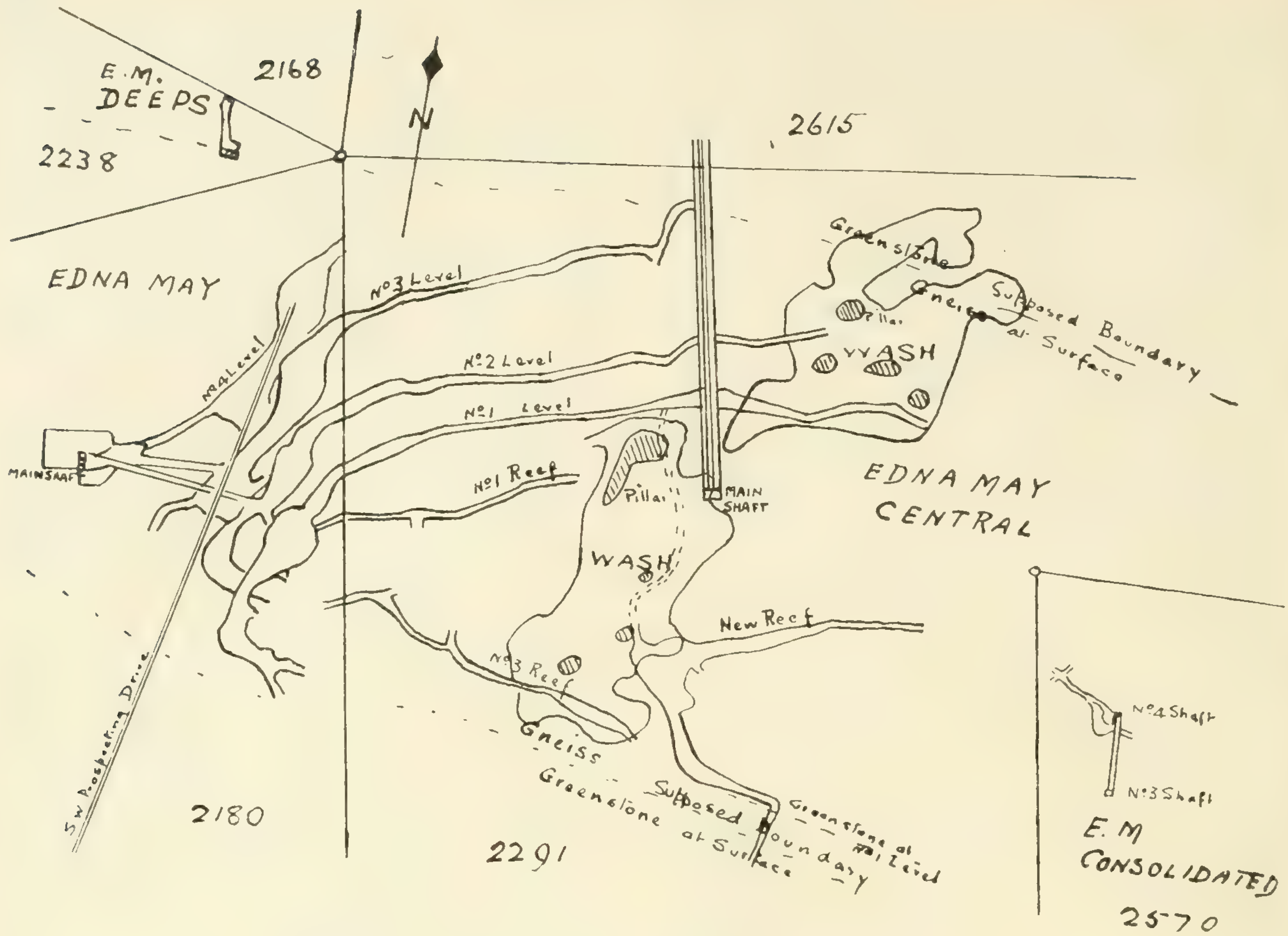
The nine sources of efficiency loss are always present, but any or all of them can be kept down to a very small quantity. On the other hand, most of them may become very serious under undesirable conditions. In general we can say that entire disregard of conditions may result in an efficiency as low as 60%, poor work 85%, good balanced operating 92%, and efficiency regardless of expense 99 per cent.

THE EDNA MAY GOLD MINES, WEST AUSTRALIA.

With the older gold-mining centres in West Australia declining, new districts are eagerly sought. Westonia is a district of some promise, and many references to it have been made in the pages of the Magazine. We quote at some length herewith from an article by T. Butement and B. H. Moore, appearing in the December issue of the *Mining and Engineering Review*, of Melbourne.

The Edna May and the Edna May Central are the principal mines at Westonia, a township about six miles north of Carrabin, a station on the Fremantle-Kalgoorlie line, 207 miles from the coast. The prospectors of the Edna May mine were Messrs. Annear and Williams, who sold out to a company formed in January 1913. The purchase price was £8,000 cash and 1,600 paid-up shares. The capital of the company is £25,000 in 50,000 shares, of which 7,000 are yet in reserve. The leases of the companies owning the two mines adjoin one another, and the workings are chiefly on the same veins. These veins occur in an elliptical area of gneiss or granitic schist trending in a direction about N. 75° W., with a length of apparently 50 chains and a maximum width of about one-quarter of that. This gneissic formation occurs in an area of greenstone. At a distance of a little over a mile to the southward is a large development of granitic rock, while at a somewhat greater distance on the west side is another large area of the same rock. In the early days the fact of the veins occurring in a granitic rock was in many quarters, in view of the unfavourable results of similar occurrences on other fields, sufficient to condemn. Further, the peculiar shape of the orebody in the principal mine—the Edna May—coupled with the existence of dykes of the gneissic or granitic character cutting the veins in places, seemed to emphasize the uncertainty. Except these two mines, there are in West Australia at the present time no mines of any importance in granitic country. It would appear that this gneissic area dips northwards in the surrounding greenstone and carries the payable veins with it. It is characteristic that no values of moment have been found in the greenstone, and exploratory work in both mines has disclosed greenstone, practically on the foot-wall. In the Edna May at the No. 1 level, 73 ft. vertical, a cross-cut has been run out in a direction somewhat west of south for several hundred feet in greenstone without finding anything of value.

The Edna May mine has been highly profitable from the start. The first crushing — 840 tons — yielded £7,700. An inspection of the mine plans shows the peculiar yet consistent shape of the orebody from level to level. At its northern end it crosses the boundary into the Edna May Central, where it has been opened up on three levels, but without the bulges which



Sketch Plan of the Edna May Group of Mines.

characterize the western end. On this end as one proceeds southwest from the boundary at a distance of about 50 ft. roughly, in each level, is a bulge of good ore up to 40 to 45 ft. wide. Again, at a distance of about 200 ft., after cutting down to as small as 12 ft., the ore widens and turns round at right angles in a southeast direction, and is for some 70 or 80 ft. or more a considerable body. The result is that while the general dip of the orebody, having regard to the portion spoken of, is about 60° to the northwest, the pitch of the shoot appears to be northwards at an angle of 47°.

The various levels to the No. 4, or 300 ft., are 75 ft. apart. The main shaft — three compartments — lies about 220 ft. northwest of a point approximating the middle of the outcrop and is now nearly 400 ft. deep. No. 5 level is being opened out. An excellent idea of the average width of the vein is given by a section opposite the main shaft, where the horizontal thickness varies from 20 to 25 ft, or more.

Besides the main vein is a second known as the No. 2 reef (known as No.1 reef in the Central) which strikes about N. 65° E, and joins with the main reef near the right-angled bend. To the end of September the Edna May has yielded gold valued at £428,010, from 101,154 tons crushed. The company has also paid £214,250 in dividends.

On the Edna May Central the main shaft is an underlie at 40°, and is about 530 ft. east of the Edna May main shaft. Its dip is northerly, following the average dip of the same vein as the other mine, but in the Central this vein strikes about N. 70° E., and the dip is rather flatter. The Central workings are extensive, and comprise, besides levels on the main vein, levels on the Nos. 1 and 3 reefs, workings on two large bodies of "wash" opened up east and west of the main underlie, and of workings on the recently discovered new reef. Most of the work lies on the west and southwest side of the shaft, between it and the boundary. The average width of the veins is not as great as in the neighbouring mine, and shows none of the large bulges, the only tendency to the latter being in the new reef where it takes a sudden turn. Widths of 12 ft. and up to 16 ft. are met with in places, except in the No. 1 reef, which is consistently small, mostly not above 3 ft. wide.

The wash was discovered two years ago just over the back of the No. 1 level, whence it was opened up by rises. It consists of gravel from sand size upward cemented with kaolin matter. Many of the stones are subangular, showing that it must have deposited very near the point of origin. Under the wash is a bed of decomposed kaolin rock, while above it to the surface is a thickness of 55 or 60 ft. of the well-known cement of the goldfields. There can be little doubt that the base of the wash was once the surface of the ground, possibiy a shallow valley which has since been filled up to the present level at least. The wash has been worked in two areas of nearly equal extent, about 20,000 sq. ft. each, one on the east side and the other on the west side of the main shaft, under which it is no doubt continuous. The thickness of the eastern body is from 4 to 5 ft., that of the western body not so great. The average value is 5 or 6 dwt. per ton, but runs up to 10 dwt. or more. The lowest part of the wash appears to be near the shaft. In cross-cutting from the No. 1 level southwards to come under the body on the west of the shaft and open it up by rises for convenience in extraction the hitherto unknown vein, now called the new reef, was discovered about the southern limit of the wash. This has since been driven on east and west and opened up south, and in its bulgy nature compares somewhat with the behaviour of the southern end of the main vein in the Edna May. It has generally been a good deal richer than the average of the ore from the other veins in this mine. West of the south end of the wash lies the No. 3 reef, striking about southeast from the boundary line. The Central mine to the end of September had crushed 64,172 tons for gold valued at £66,373.

From a metallurgical aspect the ore presents no difficulties. It consists of a white quartz through which the gold is disseminated in a finely divided state, and contains very little pyrite. The ore may therefore be said to be a clean free-milling ore, and the main question to be considered in regard to its metallurgical treatment was one involving the possibility of securing a maximum economical extraction by amalgamation alone or by amalgamation and cyaniding. As, however, the gold is very fine, it is imperative that fine crushing must be resorted to in order to obtain a satisfactory extraction. This necessitates consideration of the further question whether crushing shall be carried out in such a manner as to effect a separation of sand from slime, with subsequent distinct treatment of the two products separately, or whether the whole of the ore shall be slimed and treated by one of the regular methods of slime treatment.

Water supply for treatment purposes presents no difficulty, as the Edna May mine makes sufficient water to keep the two mills supplied with more water than would be required for treatment purposes for a considerably larger tonnage of ore. The Edna May mine pumps from 900,000 to 1,000,000 gallons of water per day. This mine water contains about 3% of dissolved solids, but appears to present no difficulties in milling or cyaniding.

The larger of the two mills is that of the Edna May mine. This plant consists of breaker, 10 stamps of 1,250 lb. each and two grinding pans, one to each five head of stamps. The pulp from the mortar-boxes passes over a short V-shaped amalgamating apron plate, which serves as a collecting box for the pipe leading to the grinding pans. The grinding pans are the ordinary 5 ft. Forwood-Down type, fitted with Freeman classifier discharge, and are used as amalgamators as well as fine grinders. The discharge from the pans, consisting of sand and slime pulp, passes over two amalgamating tables, and thence to the sump of a tailing pump which elevates the pulp to the cyanide section. The water is made alkaline by the addition of 8 to 10 lb. lime per ton of ore. Approximately 80% of the gold is recovered in the mill, and of the amalgam obtained, practically 50% is obtained from the daily clean up of the apron plates and the amalgamating tables, the remainder being obtained from the monthly clean up of the grinding pans.

The pulp from the mill is elevated to two Caldecott cones in series, where the sand and slime are separated. The overflow is elevated to a thickener, of a somewhat similar type to the Dorr, 25 ft. diameter by 8 ft. deep, which is fitted with curved rotating arms of 3 in. by ⅜ in. angle iron set at an angle of about 5° with the horizontal. These arms are bent to shape and are stayed by tie rods. The arms make one revolution every three minutes. The overflow comes off quite clear, while the underflow which contains about 55% of moisture passes by way of a launder to Trent slime plant. The underflow from the Caldecott cones goes to the sand-collecting vats, six in number, of galvanized iron, 23 ft. diameter by 8 ft. deep. The treatment vats beneath are of similar construction to the collecting vats, but 25 ft. diameter by 6 ft. deep, and having a capacity of 100 tons. The charge of sand is given six days' treatment with 0·15% KCN solution and four washes of weak solution 0·03 to 0·04% KCN. The slime-treatment plant consists of three Trent continuous decantation tanks of steel, 30 ft. diameter by 18 ft. deep, each having a capacity of 400 tons. This plant is the first of this type installed in Australia.

GOLD MINING AND WAR PROFITS TAXATION.

The *Monthly Journal* of the Chamber of Mines of West Australia for September contains an article by W. A. Macleod protesting against the undue taxation of gold mines for war requirements. We quote this article at some length, as we desire to give voice to Australian opinions on this subject. He draws attention to the fact that unlike many industries, gold-mining operations are subject to a comparatively brief existence. The spirit of venture is behind all its achievements, the element of risk is high, the prizes few, the blanks many and soon forgotten. The Great Boulder Proprietary at Kalgoorlie has paid its shareholders 25% on their investment for many years, yet averaging, in West Australia, the prizes, large and small, with the blanks, the industry has only paid about 3% on the total capital invested.

An inducement of a possible profit of 3% will never be sufficient incentive to attract capital to gold-mining, nor will 6%, the equivalent of the rate of interest proposed to be allowed by the Federal authorities as presumably a fair rate of profit. Where there is exceptional risk investors look for a proportionately high rate of interest, and the very nature of gold-mining makes it a striking illustration of this principle. Legislation must distinguish between it and other industries, and before it can do so it is necessary to define as closely as possible what is a fair mining profit. Little money for mining ventures was available in London in pre-war times without the expectation of at least a 17% dividend, and American mining houses consider business unattractive unless there is a prospective return of 20%. It may be said that the same scale is operative in inducing Melbourne capital to invest in West Australia. Without this expectation the industry will decline and ultimately vanish. It has to be borne in mind that a large proportion of the dividends received by shareholders in gold mines is simply amortization of capital, and the rate of amortization is high by reason of the short life and high risk.

The profits earned by a mine from month to month and year to year vary within limits dependent on certain factors, the most important of which are grade of ore, attainable extraction, and working cost. The grade of ore mined is maintained as closely as possible at a uniform value, yet small fluctuations are unavoidable. If such fluctuations are below the average grade, returns diminish, but if above they increase. On an output of 10,000 tons per month an increase in grade value of 1s. per ton for a period of one year amounts to £6,000, an appreciable sum if taxed at the rate of 50%, as would be the case under the proposed Federal enactment. Such fluctuations are natural to the industry and are in no way due to war conditions. It logically follows that surplus profit so earned cannot justly be taxed as War Excess Profit. Similar and even much greater fluctuations occur in tributers' operations and in the working of small mines. The gold-mining industry embraces not only the operations of the large and well-known mines, but also those of smaller companies and syndicates, of tributers, and of prospectors. The large mines are, all of them, working from year to year at greater depths. The Ivanhoe shaft is now down to 3,620 ft., the Golden Horse-Shoe 3,110 ft., and the Sons of Gwalia nearly 3,500 ft.; these depths must further increase and concomitantly working costs will increase and profits diminish.

There are other factors of a more or less abnormal nature at present responsible for a further reduction in profits and due directly to the present war. The price of all mine requirements in the way of explosives and general stores has risen very rapidly, and is now near a 30% all round advance. As such commodities are responsible for about two-fifths of the working expenses of the larger properties, this alone is equivalent to over a 10% rise on working expenses. To some extent this abnormal condition has been compensated by stringent economies, but it must be considered as strongly operative until the termination of the war and for some time thereafter. This loss is accentuated by an acute shortage of efficient labour and by a consequent increased proportion of unskilled labour, both resultant from recruiting and other causes.

The ability of mines to pay taxes is largely governed by the four factors referred to. Two of them, increasing depth and decreasing grade, permanently diminish ability to pay; the other two, stores and labour, may be of a temporary nature, but must prevail until the end of the war and for some time thereafter. Clearly the ability of the gold-mining industry to pay taxes is rapidly declining, and this is further confirmed by the number of mines which have in the past two years either shut down or curtailed operations, as also by the number of large mines now operating on a marginal profit.

The gold supply of a nation is a factor influencing its credit, so it is the bounden duty of the mine owner and worker, on the one hand, to secure the maximum output of gold, and of the State, on the other hand, to encourage and develop to the utmost such a vital industry. How far the application of war profits taxation will assist this industry is a matter of no doubt. Mines, and some of the largest, now operating at a marginal profit, though not of interest from a tax-paying aspect, are a very solid asset to the Commonwealth as gold producers and wage payers, and those responsible for their operations have a weighty burden to shoulder. It is a matter for consideration whether such enterprises should not be subsidized. The financial assistance accorded by the Government to one large mine in West Australia has been a sound investment both to the community and state.

The principle underlying the proposed war profits tax appeals to all as entirely just and its introduction as opportune. If any trade or business makes additional profits as the result of the war extra taxation is unquestionably just. With the exception of taxation on development expenditure, mining companies have been prepared to pay, and are paying already, additional taxation and a satisfactory compromise has been effected regarding development expenditure. However hard it may be, they must be prepared to further share the national burden, but they cannot be expected to pay a tax on profits which do not exist. The proposition can be affirmed without fear of contradiction that it is impossible for a gold-mining company to make additional profits as the result of the war. Industries rightly affected by the proposed tax are such as have secured either an increased production of, or an increased price for some commodity by reason of the war. The product of a gold mine is gold. The price of gold is fixed, or is said to be fixed, but in reality it has dropped, as the exchange value of each sovereign in mine stores is considerably less than before the war. It is incontrovertibly clear that, by reason of the so-called fixed price of gold and increased cost of stores, gold mines cannot make increased profits as the result of the war.

Certain gold mines may show an increased output and a profit now as compared with the pre-war years. The Great Fingall for a long period laboured under heavy disadvantages, but is now making profits due, not to the war, but to the overcoming of these difficulties. The Edna May, as another case, would be subject to heavy taxation as it was not operating extensively before the war. In this case a 6% allowance of profits for pre-war conditions, or even a 20% allowance, is grossly unjust, and the only just assessment would be on the assumption that recent profits are normal, therefore the tax is inapplicable.

The imposition of this tax will restrict the cash resources of a number of mines. This, in turn, generally leads to the restriction of development operations and curtailment of the life of these mines. This in itself is serious, but would to some extent be met if new properties were developed to replace those dropping out of the ranks. It is well known to those who in West Australia represent outside capital that recently there has been a suspension in the development of fresh properties. Investors are reluctant to take any interest in such ventures, risky at all times, but now further handicapped by the possibility of the absorption of 50%, and possibly, at a later date, of a greater percentage of any profits earned. A disastrous future is obvious. Legislation of the nature of that proposed is not only unjust and inexpedient, but invites mining companies to seriously consider their shareholders' interests. A mine may have a large tonnage of ore reserves made up of blocks of varying grade, and may well consider the advisability of mining for the present its lower grade sections at a reduced output and profit. So far no mines have done this, nor have any proposed so doing. They have loyally and patriotically striven after a maximum output, and it can hardly be conceived that the Federal authorities would so unjustly attack the industry as to force shareholders to consider such a contingency.

SHORT NOTICES

Coal-Cutting Machine.—At a meeting of the Scottish Branch of the National Association of Colliery Managers held at Glasgow in December, M. Gunnis read a paper on mining problems at the Giffnock colliery in relation to the use of coal-cutting machines. The author recorded his experience of a difficult case. The seam varied in thickness from 22 in. to 25 in., and lay 4 ft. underneath the position of a coal seam already worked out. The intervening 4 ft. consisted of a mass of fireclay and ironstone balls. The only method of working this seam with any degree of economy was by coal-cutting machinery. An ordinary disc coal-cutter was tried, but, owing to the width necessary to allow such a machine to travel along the face, together with the nature of the roof which had to be entirely carried on bars, the venture did not meet with such success as to warrent its continuance. It was obvious that the condition demanded a coal-cutter of the least possible width, as short as possible, and not too cumbersome, so that in the event of a closure, which was common in the first venture, it could be moved with the least possible inconvenience. The demands, though seemingly moderate, were beyond the scope of any coal-cutter of which the author had had previous experience. Eventually, however, they were successfully met by the use of a Sullivan "Iron-clad" longwall coal-cutter, driven by a multipolar compound-wound direct-current motor of 30 hp. The overall dimensions of the machine were 7 ft. 8 in. long by 29 in. wide by 17 in. high. It could pass along the coal face in a width of 30 in., which was a small area of roof to support, 3½ ft. bars being of sufficient length, and their thickness being in proportion to their length, and the weight they were expected to carry. The cutting was done by means of a chain travelling round an oblong jib at the rate of 500 ft. per minute. This might seem a high rate to travel, but the makers claim that it tends to greater efficiency. The author's experience leads him to believe they are correct. The author proceeds to give his views of the performance of this machine. The jib having a slight inclination forward has the effect of drawing the machine hard into the coal face, which obviates the necessity common to other types of coal-cutters of keeping the machine to its work. The jib is somewhat similar to the bar, in so far as it can describe a semi-circle, which admits of the machine being useful in winning fresh ground. An effective method is adopted for putting the cutter-chain out of action while moving the machine with the jib from underneath the coal. For the purpose of haulage, a chain is employed. This goes round sprocket wheels on the front of the machine, and is fixed at any convenient distance ahead. This method gives a regular and steady movement, and tends to the economical use of power. The handling of the machine is easy, the whole mechanism, including the motor, being actuated by three handles.

Salt in Sze-Chuan.—In *Metallurgical and Chemical Engineering* for January 1, H. K. Richardson gives a lengthy and detailed account of the production of salt in Sze-Chuan, China. This subject was briefly discussed by H. W. L. Way in his article on the minerals of Sze-Chuan published in the July issue of the Magazine. Mr. Richardson's paper constitutes a useful amplification.

Utilizing Waste Heat.—At a meeting of the American Society of Mechanical Engineers held in December, Arthur D. Pratt read a paper on the utilization of waste heat for steam generating purposes. This paper is reprinted in *Metallurgical and Chemical Engineering* for December 15 and January 1. The author describes the use of boilers, both of standard type, and of special design in connection with dust-laden gases, for the purpose of utilizing waste heat from open-hearth and other metallurgical furnaces, coke ovens, cement kilns, etc. He states that in the aggregate 11,000 horse-power is obtained in this way from zinc-distilling furnaces in the United States. The temperature of these gases averages over 1,700°F. and is in some designs as high as 2,000°F. At the nickel-refining plant of the Orford works, 3,000 h.p. is generated by steam boilers heated by gases averaging 1,700°F.

Canadian Metallurgical Progress.—In the January *Bulletin* of the Canadian Mining Institute, Alfred Stansfield, professor of metallurgy in McGill University, reviews the progress in metallurgical operations in Canada during 1916. Electrolytic zinc is being produced at Trail, British Columbia, and at the same works copper is being refined. At Lachine, the Dominion Copper Products plant is turning out copper and brass manufactures intended for use by the Munitions Board. The increased demand for antimony led to the opening of mines and the erection of a smelter at Lake George in New Brunswick. Magnesium is being produced in the Shawinigan district. Molybdenum concentrates are smelted at the Belleville and Orillia plants for the production of ferro-molybdenum. At McGill University experimental work has given promising results in connection with the electric smelting of titaniferous iron ores for the production of pure iron and ferro-titanium. An electric furnace has been erected at St John's, Newfoundland, for the treatment of copper ores, but the scale of operations is not large.

A Source of Potash.—The January *Bulletin* of the American Institute of Mining Engineers contains a lengthy paper by R. J. Wysor, superintendent of the blast-furnaces of the Bethlehem Steel Co., describing the recovery of soluble potash salts from the dust of iron blast-furnaces. About four years ago he was analysing the fine yellowish fume that accumulates in the stoves, having settled from the blast-furnace gases used for heating purposes. He found about 7% of soluble potash in it. After the war commenced and the German sources of potash salts were cut off, he offered this dust for sale as a fertilizer, and is now selling it for this purpose. The present paper is devoted to investigations as to the source of the potash. He finds fractions of potash in the iron and manganese ores. He also investigates the manner in which the soluble compounds are formed.

RECENT PATENTS

2,713 of 1916 (102,411). F. A. Eustis, C. P. Perin, and Moa Bay Iron Co., New York. A method of smelting Cuban iron ores containing nickel having for its object the production of an iron convertible into nickel steel.

12,491 of 1916 (102,595). F. Fouarge, Swansea. Roasting furnaces for treating sulphide ores and concentrates.

17,743 of 1915. G. Michaud and E. Delasson, Paris. Improvement in the process described in patent 614 of 1915, for reducing tin ores at a low temperature without the formation of slag, and the subsequent recovery of the metallic tin by electrolysis or as chloride.

16,543 of 1915. W. F. Lamoreaux, Isabella, Tennessee. Improvements in patent 2,834 of 1915 for producing elemental sulphur from sulphur dioxide by passing the latter continuously over incandescent coke.

3,184 and 3,186 of 1916 (100,154 and 101,620). Deutsche Gold und Silber Scheide Anstalt, Frankfort on Main. Manufacture of perborate of soda.

8,449 of 1916 (102,693). E. J. Lovegrove, London. Improved method of recovering solder from waste tin cans in refuse destructors.

10,933 of 1916 (101,339). Metals Research Co., New York, and E. R. Weidlein, Thompson, Nevada. Improvement in patent 10,500 of 1914 for precipitating copper from sulphate solution by means of sulphurous acid.

346 of 1916 (108,828). P. Marino, London. A cobalt-silver alloy for electroplating, deposited electrolytically from a bath composed of a solution of a cobalt salt or oxide and a silver salt in sodium thiosulphate or bisulphite.

NEW BOOKS AND OTHER PUBLICATIONS

Principles of Oil and Gas Production. By R. H. Johnson and L. G. Huntley. Cloth, octavo, 390 pages, illustrated; price 16s. New York: Wiley & Son; London: Chapman & Hall.

An important element in this most useful work is its protest against the sacrifice of verities at the shrine of St. Textbook, and especially in regard to the predominant importance so generally assigned to geological structure, regardless of the form and texture of the reservoir rocks whence oil and gas can be drawn.

While holding no brief for the hierarchy of the cult referred to, I may point out in their palliation the necessity for generalized statements in treatises covering the whole of a broad subject. Such statements, like the averages in statistics, may coincide with no single instance, for nature abhors uniformity as much as she does straight lines, true circles, plane surfaces, or any of the mathematical fictions which we find necessary to our limited powers of dealing with her infinite variety of conditions.

Also, while cordially assenting to the authors' propositions of the transcending value of the form and texture of oil-rocks, especially where lenticularity produces a more or less sealed dome in the heart of a syncline, or where cementation seals oil from escape in an otherwise open course, we must not forget that these local conditions are discoverable only by extensive drilling, with careful study of the data obtained thereby, and that, for fields of limited area, such complete knowledge is "wisdom after the event," *post mortem* diagnosis. The prospector of a virgin field can work only from the general indications of structure as visible at the surface, and assume a fair degree of regularity in the beds concealed in the cores of anticlines. This principle would hold good even in series whose exposed members were visibly of great lenticularity or irregularity in respect of porosity, conditions involving only greater care in correlating well-sections with each other, so that attenuations, expansions, and variations of texture should be recognized, and their deceptive influence nullified in further forecasts.

It may be noted that the authors, in dealing with the closeness of well-sites, represent the area of action of each well by uniform circles, as a convention necessary for calculation, although we may feel sure, *a priori*, that these areas are neither uniform nor circular, and that they are continually changing by the subterranean passage of gas, oil, and water as exploitation proceeds.

With each succeeding well, provided that proper records are preserved, the knowledge of the factors of shape and texture of the oil-rock and associated beds increases, and these, in perhaps many cases, may be of paramount importance. But here again, structural conditions may largely affect their relative values. In beds lying at high angles, lenticularity is evidently of less effect than in practically horizontal strata, while in thick sands, cementation of even large masses would but slightly affect the continuous porosity of the whole, although where the drill met with such, temporary discouragement might ensue. A case *per contra* is on record where test borings on the line of a projected railway found only loose sand, while the subsequent cutting encountered huge masses of concreted rock, involving heavy cost in removal.

The authors judiciously allot a very considerable portion of the book to these questions of the conditions of occurrence of oil and gas, treating in less detail the mechanics of drilling and exploitation as adequately handled in many other works. Writing principally for American readers, their evidence and deductions mostly refer to the conditions obtaining in the oilfields of the United States. The chapters on leasing lands and on natural gas, with that (110 pages) describing the various fields from the Arctic regions to the Mexican Isthmus, occupy nearly half the work, the latter in particular being a most useful summary, with copious references to the literature affording detailed information.

Throughout we find most valuable hints drawn from practical experience, as to the relative importance of data, from the purely trivial to those of supreme relevance, while the index, exceeding ten pages, furnishes an adequate guide to the whole, except that apparently it omits the last chapter (Oil Market and Future Supply), and the Appendix, with its useful tables on the flow of gas, areas of pipe-sections, expansion of gas, conversion of Baumé and gravity readings, etc. Though taken from other authors, these should be noted in the index.

A geological map of North America, in 20 colours, is appended, without scale, but approximately 62·5 miles to an inch.

W. H. Dalton.

Handbook of Rock Excavation; Methods and Costs. By Halbert Powers Gillette. Pocket size, cloth covers, 830 pages, with illustrations; price 21s. net. New York: Clark Book Co. For sale by *The Mining Magazine*.

Mr. Gillette is one of the most useful of American writers on problems relating to the removal of rock and earth. He is by association a civil engineer, and he has devoted himself to the problems coming before the engineering contractor. To him, mining and quarrying are side lines, but to the mining engineer his books are of very direct interest. A dozen years ago he published a book with the present title, and it received immediate recognition by civil and mining engineers. The book now issued carries the same title, but it is entirely newly written, and is nearly three times the size. The author promises two companion volumes, one on earth excavation, and the other on tunnels and shafts.

It has always been a grievance with us, and also with the budding mining engineer, that professors of mining and authors of mining books try to include in one volume the whole range of subjects that a mining engineer should know. The consequence of this policy of authors is that the multitude of subjects receive little detailed attention. We should like to see the general engineering subjects treated separately, and the more distinctly mining subjects treated in greater detail. For instance, the mining book would discuss the methods of following and developing an orebody and the most economical methods of raising the ore from a proved orebody. The methods of sinking a shaft and driving an adit are the same in civil and mining engineering, and in many a case the miner might with advantage take pause and adopt the slower but surer methods of the civil engineer. These remarks serve to indicate the value of Mr. Gillette's book. He writes for the civil engineer and his advice is equally good for the miner. For this reason his book, covering a definite scope, is to be recommended. Nearly one-half of the book is devoted to drilling. Hand drills, rock drills, diamond drills, shot drills, are discussed in great detail. We note with interest the chapter on the survey of drill-holes. Another long section is devoted to explosives and blasting operations. Loading ore and stone is also treated fully. Other sections deal more specifically with railroading, canal construction, building under water, quarrying, and other civil engineering subjects.

The Geology of the Lake District. By J. E. Marr, D.Sc., F.R.S. Cloth, octavo, 240 pages, illustrated; price 12s. 6d. London: Cambridge University Press.

The Lake District is well known to geologists as one of exceptional interest, largely arising from the variety of structure and scenery presented in a relatively small area. Professor Marr has written this book primarily for the geological student, but in such a charming and entertaining manner that it should appeal to a much wider public. It is indeed a book to be read and prized by the casual visitor or the holiday maker who would seek to obtain the maximum of intellectual enjoyment or recreation from a sojourn in Lakeland. There are perhaps few who are not susceptible in a greater or less degree to the charms of Nature's beautiful scenery, and some understanding of the means whereby the landscapes have acquired their present forms can but add to the appreciation of the peculiar beauty of the district. This little book briefly tells the story of how the scenery of Lakeland has been built and sculptured from the crude rough sediments and igneous rocks. Although the treatment is brief and terse, it is comprehensive and most interestingly written, so that the general reader may gain a complete understanding of the broad outlines of the geological history of the district and the geological meaning of the scenic variety, while by means of the bibliography it serves as a key volume for the purposes of more exhaustive study. Professor Marr remarks by way of preface that Lakeland is one of Nature's laboratories, but it may be as well to add that it is one of exquisite geological artistry, appealing powerfully both to the æsthetic and scientific senses, so much so that its comeliness makes the term "laboratory," which is apt to be associated in the mind of the general reader with a none too attractive edifice containing medleys of bottles, benches, and apparatus, seem almost too commonplace for the purposes of adequate comparative description.

From the professional viewpoint of the mining engineer and economic geologist the book is of considerable interest as a study in the relationships of geological structure and history to scenery. The ability to correlate rapidly physical features with geological structure is one of importance to the professional economic geologist, and from this standpoint the book will repay careful study. There is still much room for further research, and Professor Marr suggests several lines of inquiry that should prove attractive to students who may aspire to add to our knowledge of the geology of Lakeland.

The work is freely illustrated with diagrams and photographs, is of the best quality in every way, and deserves to be widely read. It is to be hoped that it will not only help to create a more widespread interest in the geology of Lakeland itself, but will stimulate interest in geological science among a larger public, who may well be attracted by the special history of those beautiful scenic effects produced by the prolonged and varied action of the universal geological agents.

W. H. GOODCHILD.

The Mines Handbook. By Walter Harvey Weed. Cloth, octavo, 1,700 pages; price 42s. net. New York: The Stevens Copper Handbook Company.

This book is a successor to Stevens' Copper Handbook. The original book covered the copper-mining companies of the world. The present volume is confined to companies known in North America, and the scope has been widened so as to include all non-ferrous metal mines. We hope all the copies are not as badly bound as those we have seen.

Mining Mathematics: Senior Course. By S. N. Forrest. Cloth, octavo, 320 pages; price 5s. net. London: Edward Arnold.

Method for Measuring Viscosity of Blast-Furnace Slag at High Temperatures. Alexander L. Field. Technical Paper 157, United States Bureau of Mines.

Underground Wastes in Oil and Gas Fields and Methods of Prevention. W. F. McMurray and J. O. Lewis. Technical Paper 130, United States Bureau of Mines.

Ore Sampling Conditions in the West. T. R. Woodbridge. Technical Paper 86, United States Bureau of Mines.

Safe Practice at Blast-Furnaces, a manual for foremen and men. F. H. Willcox. Technical Paper 136, United States Bureau of Mines.

Review of the Geology of Texas. J. A. Udden, C. L. Baker, and E. Boese. Bulletin 44, 1916, of the University of Texas.

TECHNICAL PAPERS FOR THE MONTH

BRITISH

Chemical Society.—*January 18:* Alloys of Copper and Tin, Aluminium, and Gold, C. T. Heycock.

Colliery Guardian.—*January 12:* Coal Supplies at Spanish Ports, F. J. Warden-Stevens. *January 19:* Organization of the Coking Industry, L. T. O'Shea, address to the Coke Oven Managers' Association; The Afforestation of Dumps. *January 26:* The Chalmers-Black Indicator for Winding Engines. *February 2:* Physical Properties of the Materials of Coke-Oven Bricks, Professor W. G. Fearnsides; Sirocco Air-Filter, for purifying air used for cooling turbo-generators.

The Engineer.—*January 5:* Coal-Loading Piers and Plant at Port Kembla, New South Wales, E. M. de Burgh. *January 12:* The Umberumberka Water-Supply for Broken Hill; What Industry owes to Science; Ammonia-Soda Process, Coal, and Coal-Gas. *January 19:* Use of Coke and Coke Breeze for Steam Generation, J. B. C. Kershaw; An Old Pumping Engine in use for 125 years at Pentrich Colliery, Derbyshire. *January 26:* What Industry Owes to Science; Dyes, Explosives, and Cellulose. *February 2:* What Industry Owes to Science, Cellulose Oils and Fats, Soap and Candles, Edible Fats; Steam Turbines for Land Purposes, H. L. Guy; Removal by Blasting of Coenties Reef in New York Harbour.

Engineering.—*January 5:* Pulverized Coal for use in Locomotives, J. E. Muhlfeld, extracts from a paper read before the American Society of Mechanical Engineers. *January 12:* The Universal Gravity Bucket Conveyor, G. F. Zimmer; Chromium and

Chromiferous Iron Ores. *February 2:* Account of Sir James Dewar's Lecture at the Royal Institution on Soap Bubbles of Long Duration.

Geological Magazine.—*January:* Geology of the Egyptian Oilfield, W. F. Hume.

Institution of Civil Engineers.—*January 9:* Recent improvements in Dredging Machinery, W. Brown, relating to harbour, canal, and river work.

Iron & Coal Trades Review.—*January 5:* Blowing and Power Plant for Blast-Furnaces at Millom; Winding Engines at Baillieston Colliery, Scotland, employing a modified form of Ward-Leonard control; Gas-fired Brick-making Kilns at Glenboig, Scotland; Protection of Mining Cables, Christopher Jones, paper read before Association of Colliery Managers; Coal-Cutting by Machinery, M. Gunnis, giving particulars of the performance of the Sullivan coal-cutter. *January 12:* Principles involved in Computing the Depreciation of Plant, F. Gill and W. W. Cook, paper read before the Scottish Section of the Institution of Electrical Engineers [continued January 19]. *January 19:* Burner for Burning Blast-Furnace Gas in Steam Boilers, J. J. Mackinlay; Coal-Cutting and Conveying at Pender Colliery, Staffordshire. *January 26:* Electric Arc Steel-Furnace; Dust-tight Mine Cars, J. W. McTrusty, paper read before the National Association of Colliery Managers; Turbo-blower for the Barrow Hematite Steel Co.; Compressed Air for Coal Cutters, discussion at National Association of Colliery Managers; Patent Litigation with regard to the Working of Tungsten Metal. *February 2:* The Greaves-Etchells Electric Steel Furnace.

Society of Chemical Industry, Liverpool Section.—*January:* Use of Peat in Gas-Producing Plants, E. C. C. Baly, giving details of an installation in Ireland.

Society of Glass Technology.—*January 18:* British Glass Sands, their Location and Characteristics, Dr. P. G. H. Boswell.

Quarterly Journal of the Geological Society.—*January:* Accessory Minerals of the Lake District Granites, R. H. Rastall and W. H. Wilcockson; Rocks of the Lyd Valley, Dartmoor, F. P. Mennell.

Colonial

Canadian Mining Institute Bulletin.—*January:* Canadian Metallurgy during 1916, Alfred Stansfield; Gold Mining in Nova Scotia during 1916, S. N. Graham; Mining in Quebec during 1916, T. C. Denis; The Year in Ontario, T. W. Gibson; The Mining Situation in Manitoba, R. W. Wallace; Mining in Alberta, J. T. Sterling; British Columbia Mining, E, Jacobs; Iron and Steel Resources and Industries of Canada, Thomas Cantley.

Canadian Mining Journal.—*December 15:* Iron and Steel Industry in Nova Scotia, F. W. Gray.

Chemical, Metallurgical, and Mining Society of South Africa Journal.—*November:* Ore Treatment at the Falcon Mine, Rhodesia, H. R. Adam; Neutralization Effect of Ash on Acid Sand in Stope-filling, C. Toombs; Flotation Concentration Experiments on Transvaal Gold Ore, F. Wartenweiler.

Federated Malay States Chamber of Mines Magazine.—*December:* Tin-dredging in the Federated Malay States, A. C. Perkins, with discussion by J. M. Newman, F. E. Mair, A. Colledge, T. R. A. Windeatt; Particulars of the Plants at the French Tekka Mines, the Malayan Collieries Company's Coal Mines, and the Malayan Tin Dredging Co's Mines; Returns of Output of Tin Mines in the Malay Peninsula.

Mining and Engineering Review.—*December:* The Edna May Group of Mines at Westonia, West Australia, T. Butement and B. H. Moore; The Enemy-Subject Question on the Mines in West Australia; The Blackheath Colliery, Ipswich, Queensland.

Monthly Journal of Chamber of Mines of West Australia.—*September:* Gold Mining and War Profits Taxation, W. A. Macleod.

Queensland Government Mining Journal.—*November:* Occurrence of Magnesite, Dolomite, and Magnesium Salts in Queensland, B. Dunstan; Kangaroo Hills Copper and Tin District, North Queensland.

Foreign

American Institute of Mining Engineers Bulletin.—*January:* Potash as a By-Product from the Blast-Furnace, A. J. Wysor.

Economic Geology.—*December:* The Physiographic Conditions at Butte and Bingham when the Copper Ores were Enriched, W. W. Atwood; The Measurement of Temperature in Bore-Holes, John Johnston and L. H. Adams.

Engineering and Mining Journal.—*December 23:* Barite Mining in Georgia, A. C. Vivian; Efficiency of Compressed Air Installations, II, T. Simons; Chart for Determining Heat Losses in Flue Gases, H. F. Hutzel. *December 30:* Sulphuric Acid from Copper-Smelting Gases, E. L. Larison; The Wave-Transmission System in Drilling, E. M. Weston; Assay of Gold in Copper Matte, R. E. Chase. *January 6:* Review of Output of Metals and Minerals in the United States, and of Progress in Technology. *January 13:* Idaho Placer Operations, J. Hornbein; Cadmium in Cartridge Brass, Bridgeport Brass Co.

Journal of Geology.—*January:* Suggestions for a Quantitative Mineralogical Classification of Igneous Rocks, Albert Johannsen.

Metallurgical and Chemical Engineering.—*January 1:* Recovery of Molybdic Acid from Phosphorus Filtrates, E. W. Hagmaier; The Future of the Iron Blast-Furnace, J. E. Johnson; Current Efficiency in Copper Refining, Lawrence Addicks; Nature and Origin of Petroleum and Asphalt, Clifford Richardson; Utilization of Waste Heat for Steam-Generating Purposes, Arthur D. Pratt; Production of Salt in Sze-Chuan, China, H. K. Richardson; Electrolytic Behaviour of Tungsten, W. E. Koerner. *January 15:* Analysis of Babbit Metal, E. W. Hagmaier; Vaporization of Metallic Copper in Wire-Bar Furnaces, Allison Butts; Calculation of Lead Blast-Furnace Charges for Students of Metallurgy, Boyd Dudley; Training the Works Chemist, F. E. Lathe; Automatic Liquid-Weighing Machine.

Mining and Engineering World.—*December 23:* Goodsprings Zinc-Lead District, Nevada, W. A. Scott; Tom Reed Gold Mines Property, Oatman, Arizona, C. F. Spillman. *December 30:* Saving Effected by Modern Rock-Drills, Letson Balliet; California Magnesite Industry, W. A. Scott. [Publication of this journal was suspended with the issue of December 30, the goodwill of the business having been purchased by the *Engineering and Mining Journal*.]

Mining and Scientific Press.—*December 9:* From Precipitate to Bullion, R. R. Bryan; Interview with E. P. Mathewson, T. A. Rickard; Manufacture of Chromates from Chromite, Harold Trench. *December 23:* Electrolytic Refining at Trail, B.C., T. A. Rickard [continued December 30]; The Cache Creek Dredge, Alaska, Sumner S. Smith; Metallurgical Plant of the Babilonia Gold Mines, Nicaragua, S. M. Parker, containing Holman Stamps; Analysis of Molybdenum Ores, H. Westling and C. Anderson. *December 30:* Text of the Decision Minerals Separation v. Hyde; Manganese in West-Central Arkansas, G. A. Joslin. *January 6:* Flotation in 1916.

YEARLY REPORTS OF MINING COMPANIES

Mount Lyell Mining & Railway.—This company was formed in Melbourne in 1890 to acquire a copper deposit near the west coast of Tasmania. In 1903 an amalgamation with the North Mount Lyell company was effected. The North Lyell ore is high in copper and silica, and the Mount Lyell ore is low in copper and high in pyrite, so the mixture is ideal for pyrite smelting. R. C. Sticht is general manager, and Basil Sawyer is local superintendent. The report for the half-year ended September 30 last shows that 166,497 tons of ore was mined, as compared with 168,393 tons during the previous half-year; of this ore, 84,292 tons came from underground and 18,519 tons from the open-cut, at Mount Lyell, while 57,130 tons came from the North Lyell, and 6,488 tons from the Lyell Comstock. The following was delivered to the smelters: ore from Mount Lyell 95,784 tons averaging 0·48% copper, 0·8 dwt. gold, and 1·39 oz. silver; ore from North Lyell 55,057 tons averaging 5·98% copper, 0·1 dwt. gold, and 0·32 oz. silver; and concentrate from Lyell Comstock 2,132 tons averaging 9·84% copper, 1·32 dwt. gold, and 0·66 oz. silver. The yield of blister copper was 3,173 tons, containing 3,139 tons of copper, 4,183 oz. of gold, and 170,399 oz. of silver. The flotation plant started on February 17 on Lyell Comstock ore, and it has also treated low-grade ore from the North Lyell mine. In addition to ore sent to the smelter, 7,027 tons of Mount Lyell ore was sent to the chemical works for the manufacture of sulphuric acid used in making superphosphate. Development was restricted owing to shortness of labour, but such work as was done continued to open up ore satisfactorily. The reserve on September 30 was estimated at 1,726,485 tons at Mount Lyell averaging 0·53% copper, 0·8 dwt. gold, and 1·96 oz. silver; and 1,083,211 tons at North Lyell averaging 6% copper, 0·1 dwt. gold, and 1·33 oz. silver. The accounts show a profit of £242,962, out of which £102,712 has been reserved for taxes, though the actual amount payable as profits tax is not yet fixed. We have already recorded that the company has invested £20,000 in Metal Manufactures Limited, a company which will erect works adjoining the electrolytic refinery at Port Kembla for the purpose of establishing a copper manufacturing industry for Australia; also that the lead-zinc-silver deposits in the Mount Read and Rosebery districts have been acquired and a separate company formed to work them.

Broken Hill Block 10.—At the outbreak of war, the mine belonging to this company was closed owing to the impossibility of marketing the lead product. Previously the lead concentrate was sold to German buyers, and the zinc tailing to the Amalgamated Zinc. The report for the half-year ended September 30 last shows that a contract was made in April with the Associated Smelters Proprietary for the treatment of lead concentrate at Port Pirie, and that mining and milling was resumed on May 9. During the period under review, 34,914 tons of ore, averaging 12% lead, 13·2% zinc, and 10 oz. silver, was raised and treated, for a yield of 5,226 tons of lead concentrate, averaging 60·8% lead, 8% zinc, and 32·7 oz. silver. It has been decided to instal a flotation plant to treat the slime and zinc tailing, this plant to be used conjointly with the Block 14 Company. The accounts show a net profit of £13,853, out of which £5,000 has been distributed as dividend, being at the rate of 1s. per £10 share. During the half-year, the manager, O. B. Ward, has been at Misima Island, off Papua, examining the work done on gold mines held on option, and he has issued a report. These properties have been acquired, and a new company has been formed to operate them. Particulars are given in "Review of Mining."

Broken Hill Block 14.—For some years this company had subsisted on an output of carbonate lead-silver ores by reclamation from upper levels, until shortly before the war, when a contract was made with the Junction North company, whereby the latter company treated sulphide ores. The war put an end to the contract, as the lead and zinc concentrates could not be sold. The mining of carbonate ore has, however, been continued. The report for the half-year ended September 30 last shows that 4,335 tons of carbonate ore averaging 24·17% lead and 13·02 oz. silver were sold realizing £20,076. The net profit was £6,278. Interest absorbing £1,500 was paid on the preference shares, and £5,000 was distributed as dividend at the rate of 6d. on each of the preference and ordinary shares. As mentioned in the preceding paragraph, the sulphide ore is to be treated by the Block 10 Company, the deliveries being 1,000 tons per week.

Amalgamated Zinc (De Bavay's).—This company was formed in 1909 in Australia to acquire the business of the De Bavay's Treatment Co. and to expand the scale of operations. The company owns the De Bavay flotation patents and treats zinc tailing from the North, South, and Block 10 mines at Broken Hill. The Australian De Bavay royalties are pooled with those of the Minerals Separation process, the controlling company being the Minerals Separation & De Bavay's Processes Australia Proprietary. The report for the half-year ended June 30 shows that 91,438 tons of zinc tailing was treated, for a yield of 25,669 tons of zinc concentrate, averaging 48·9% zinc, 5·8% lead, and 7·4 oz. silver per ton, together with 440 tons of lead concentrate averaging 58·6% lead, 9% zinc, and 48 oz. silver. The accounts show an income of £211,573 from the sale of concentrate, and a profit of £71,008; £75,000 was distributed as dividend; during the same period another £75,000 was distributed out of the balance brought forward from the previous half-year. H. W. Gepp, the manager, has recently returned from an extended visit to the United States, where the zinc concentrate has recently been sold, and where he has been studying electrolytic zinc methods. A company called the Electrolytic Zinc Co. of Australia has been formed, as already announced in our columns, with a capital of £1,000,000 in shares of £1 each, of which the Amalgamated Zinc holds 100,000 shares. The extent of participation of other companies which have been invited to join has not yet been determined. The first unit will have a capacity of 10 to 11 tons of zinc per day, and will call for 4,000 h.p., the cost of which will be £3. 10s. per horse-power year, obtained from the Hydro-Electric Department of Tasmania. The plant is to be gradually increased to a capacity of 125 tons per day, absorbing 50,000 h.p., which will be charged at the rate of £2 per horse-power year.

Chillagoe.—The report of this company now issued covers the year 1915. The company owns copper, lead, and gold mines and a smelter, and also coal mines and railways, in Queensland. During 1915 the works and mines have been closed, with the exception of the Union gold mine and the Mount Mulligan coal mine, but the railways have been in operation. At Mount Mulligan, a considerable amount of development work has been done, with satisfactory results, and the output of coal for the year was 9,545 tons. At the Union mine, bullion worth £842 was produced during the year, together with concentrate containing 321 oz. gold and 16 tons copper. The directors are not in a position to make any statement regarding resumption of operations at Chillagoe. A notice of foreclosure was given by the debenture holders, but nothing further has been done.

Deebook Dredging.—This company was formed in 1913 with offices at Ringwood, near Melbourne, to work tin-dredging ground at Renong, Siam. The London firm of Lionel Robinson, Clark & Co. are interested. Arthur H. Miles is manager. The first dredge was started in August 1914, and No. 2 a year later. The report for the year ended May 31 last shows that No. 1 ran 6,109 hours and No. 2 5,222 hours. The ground treated totalled 1,128,228 cubic yards, and the yield of tin concentrate was 358 tons, being 0·712 lb. per yard. The proceeds of the sales, after paying royalty, was £33,769, an average of £94. 4s. 8d. per ton, or 7·2d. per yard. The net profit was £9,172, or 1·95d. per yard. Since the close of the year, a serious accident happened to No. 1 dredge. The collapse of the launder framing caused the dredge to capsize and sink. To refloat and repair will involve a cost of from £4,000 to £7,000. The results of dredging, since the commencement of operations, have not been so good as expected, and the ground has been extensively re-bored so that the poorer parts may be eliminated. These bore-holes have indicated that the extent of ground carrying 2 lb. per yard is small. The poorer patches have been fairly accurately ascertained, and it will be possible to improve the average yield by avoiding these. The company owns a large extent of ground, which will take many years to treat, even when one-third is rejected as too poor.

Sissert.—This company was formed in 1912 to acquire the share capital of a Russian company called the Sissert Mining District Co., owning an estate in the Ural Mountains, south of Ekaterinburg, containing copper, iron, gold, and platinum mines. Details of the deposits were given in our issue of June 1912, and the leaching process for treating oxidized ores was described in January 1910. The report now issued covers the year ended May 31 last. The accounts of the Russian company for 1915 showed a profit of 10,744 roubles. The English company has made further loans to the Russian company, the total indebtedness being £122,316. The Sysselsky copper mine is estimated to still contain 70,000 tons of ore averaging 4½% copper. At the Gumeshevsky, 500,000 tons of oxidized copper ore remains for treatment by leaching, and at its southern end, a large body of ore averaging 2 to 3% has been discovered. The most important asset of the company is the Degtiarsky property, which has been proved by an extensive drilling campaign to contain 3½ million tons of pyritic ore averaging 2·77% copper and 3s. in gold and silver. The company has developed the Egorshinsky coal mine, which it holds on lease, and has more recently purchased the Isyhks coal mine, which is to be developed in the current year. The latter deposit contains coal of good coking quality. E. J. Carlyle, the company's metallurgist, is preparing plans for a new smelter. Norman Stines is the mining manager. William Selkirk is a director and the consulting engineer.

Pigg's Peak Development. — This company was formed in 1889 to acquire a tract of country near Pigg's Peak, in Swaziland, South Africa. Operations have been confined to the Peak gold mine, which has not so far proved a profitable venture. There have been two reconstructions, the last having been in 1898, when L. Ehrlich & Co. assumed control, with E. T. McCarthy as consulting engineer. In addition to these reconstructions, additional capital has been subscribed on two occasions, in 1905 and 1909. The issued capital is now £223,225, and there are £15,425 debentures. The report for the year ended March 31 shows that 28,590 tons of ore was treated for a yield of gold worth £26,374. The working cost was £33,501, and after the payment of debenture interest and administration expenses, the year ended with a net loss of £12,685. As regards future prospects, the ore reserve was estimated by Harold Sharpley, the manager, on March 31, 1915, at 18,261 tons; during the year under review the extraction was 28,590 tons, and since then, up to the end of November last, 17,700 tons was sent to the mill. The reserve is therefore by no means exhausted. It is the opinion of the manager that further development will lead to the discovery of additional lenses of ore. Development operations have, however, been considerably retarded, first by flooding of the mine, and afterward by drought.

Ferreira Deep.—This company was formed in 1894 to acquire property on the dip of the Ferreira mine, in the central part of the Rand. Production commenced at the conclusion of the Boer war, and the first dividend was paid in 1904. In 1912 the remaining portion of the Ferreira was absorbed, in return for the issue of 70,000 shares. The control is with the Rand Mines Limited. The report for the year ended September 30 shows that 745,630 tons of ore was raised, and after the rejection of waste, 644,960 tons was sent to the mill. The yield of gold by amalgamation was 199,036 oz., and by cyanide 72,769 oz., making a total of 271,805 oz, worth £1,130,227, being 8·45 dwt. or 35s. 2d. per ton milled. The working cost was £671,532, or 20s. 11d. per ton, leaving a working profit of £458,694, or 14s. 3d. per ton. Taxes absorbed £62,434, and £379,750 was distributed as dividend, being at the rate of 38¾%. The ore reserve is estimated at 1,632,600 tons averaging 8·3 dwt., practically the whole of this being in the deep section. Shaft-sinking has been completed, and little ground remains to be developed. Of recent years this mine has suffered greatly from collapses of the roof and shaft-pillars; these troubles still continue.

Welgedacht Exploration.—This company was formed in 1899 to acquire property in the Far East Rand, to the east of Modderfontein and Geduld, containing coal near the surface and gold below. The coal has been worked continuously since 1907. In 1905 the banket was located by bore-hole at a depth of 1,908 ft. where the bed assayed 1 oz. over 10 in. Shaft-sinking to the banket was started in 1910, but on arriving at a depth of 724 ft., water overwhelmed the workings, and nothing has been done since. The shaft was, however, utilized for the extraction of coal. The report for the year ended June 30 last shows that 127,106 tons of coal was sold, realizing £32,909, or 5s. 2d. per ton, obtained at a working cost of £28,340 or 4s. 5d. per ton, leaving a profit of £4,568. Adding interest on loans and receipts from rents, and deducting London expenses, etc., the net profit was £4,892, out of which £3,918 was distributed as dividend, being 2½% on the capital, £156,750. Two years ago, the developments were not satisfactory, and a boring campaign was started. By this means an area of 125 acres estimated to contain 1,000,000 tons of coal was determined. A shaft was sunk, and connected with the other workings by a drift. Raising of coal from the new area was commenced in October last. P. G. Hamilton Carvill is chairman of the company, and David Wilkinson is consulting engineer.

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CONTENTS.

EDITORIAL

METAL melting will be the subject of discussion at the forthcoming meeting of the Institute of Metals to be held on March 21 and 22, at the rooms of the Chemical Society, Burlington House. A consideration of methods employed for obtaining high efficiency at low cost will throw side-lights on fuel economy, one of the pressing problems of the day.

HARD things are often said of statistics and their tendency to mislead. Some of the newspapers rejoice that our foreign trade is expanding in spite of the war. This congratulation is based on the value of the monthly exports and imports. Unfortunately for the scribes, and for the country, this increase is due to higher prices, and not to a greater bulk of business. In our own pages of statistics, we have always quoted outputs and trade figures relating to all metals and minerals except gold in terms of the units of weight.

INVESTORS and speculators are accustomed to receiving rude shocks from those in control of Australian affairs. This month they are alarmed at Mr. Hughes's hint that in future neither individual nor company will be allowed to make more than a reasonable profit. The attitude of the Australian with regard to political economy is little understood in this country. For this reason we have quoted, in our Reviews of New Books this month, from a book by Professor J. W. Gregory, explaining this attitude and point of view. Professor Gregory's words are well worth serious consideration.

IN our discussion pages Mr. C. W. Purington raises the question of the necessity for a comprehensive index of the contents of all the issues of the Magazine so far published. Nobody more appreciates than the Editor the need of such an index, though he admits the possession of a good memory. Whether it would be advisable to print and publish such an index at present is an open question. In the first place paper has to be strictly economized, and second the number of readers who would require the index is difficult to gauge. Perhaps it would be best to defer preparation and publication until the completion of the 20th volume in June, 1919. The war might be over by then. We hold the matter over for the present, and in the meantime ask readers who are particularly interested in the subject to communicate their ideas to us.

AN appeal has been lodged by the Amalgamated Properties of Rhodesia against Mr. Justice Eve's judgment in favour of the Globe & Phœnix. The proceedings before the Court of Appeal will not be so prolonged as they were in the first court, for the points at issue are now much better understood, and no "fishing" will be necessary.

MANY alterations in our customs are necessitated by war conditions. One of these is the modification in the method of addressing letters for delivery in London. We would ask readers to help the postal service by remembering that our address is now: 724, Salisbury House, London Wall, London, E.C.2. The final "2" is important.

OWNERS of British lead and zinc deposits have hesitated to extend their operations owing to the lack of any guarantee of receiving a remunerative price for the concentrates. A satisfactory arrangement has been concluded with the Government on a basis similar to that already established in connection with the Broken Hill output. We hope the owners of British mines will grasp the opportunity now offered. Large sums of money are required for adequate proving and development. Capital supplied in driblets and operations akin to tinkering are not likely to lead to success.

TO mining engineers the sinking of the *Laconia* brought the touch of personal grief, owing to the deaths, due to exposure, of Mrs. and Miss Hoy, the mother and sister of an excellent American, Mr. Austin Hoy, who has won the esteem and affection of his confreres during his sojourn here. His action in pressing his services as a fighter either for his own country or for the Allies is all in one with his previously expressed desire that the United States should boldly join in the fight for civilization. It will console him to know in his hour of affliction that his friends appreciate the services he has already rendered to the Allies in other directions. Has not the coal-cutter released many miners for other service, and has not the diamond-drill located further supplies of much needed metalliferous ores?

OUR contemporary the *Mining and Scientific Press* is in close sympathy with human nature as well as with the technology of mining and metallurgy. A distinctly characteristic feature of its pages of recent months has been the publication of interviews with distinguished engineers, in which Mr. T. A. Rickard has recorded the life history of many men who have done well for the world in their own particular line. Perhaps the most instructive of all these interviews is that with Mr. John H. Mackenzie, appearing in the issue of January 27, for it shows that diligence, and force and uprightness of character still bring a man to the front in spite of lack of early opportunities for study or technical training. Mr. Mackenzie was born in Toronto of humble parentage, went to sea at 13, spent his years from 16 to 19 in a Canadian lumber camp, and then went to Nevada in 1877 during the Virginia City and Eureka booms, where he worked as a miner and timber-man. During the next few years he followed the fun of the fair in Colorado, New Mexico, Arizona, back again to Nevada, and afterward to Montana and Dakota. All this roaming provided apprenticeship. The turning point toward prosperity arrived when he went to Cripple Creek at the time of the excitement, and fell in with the late W. S. Stratton, who engaged him as manager of the Independence mine. In 1898 he joined the stampede to the Yukon. After the Whitaker Wright collapse he took charge of the Le Roi mine in British Columbia. Two years later he assisted in developing the copper property of the Nevada Consolidated, and in 1907 was appointed manager of the Goldfield Consolidated gold mine in Nevada. At the present time he is associated with Mr. F. W. Bradley in the development and mining of the great low-grade gold orebody of the Alaska Juneau company. Truly an honourable record!

COMPETITION for the presidency of a learned or professional society savours of undignified procedure, so it is a pity that the members of the American Institute of Mining Engineers have been asked to decide between Mr. S. J. Jennings and Mr. Philip N. Moore. Both are men of standing and repute, and they were practically equally acceptable to the members as president. The result of the voting was the election of Mr. Moore with 1,205 votes, as against 1,010 votes for Mr. Jennings. The new president is well known for his work in the Middle States. Mr. Jennings is better known in this country, for he was in South Africa for some years as consulting engineer to the Rand Mines group.

IF in the United States there was plethora of candidates for the presidency of the representative mining society, the opposite holds good in this country. So many of the likely presidents are away on war work, that it has been felt best to go slow for the present. By great good fortune the Institution has been able to secure a continuance of Mr. Edgar Taylor's services. He was president six years ago, and he was induced to resume the duties toward the end of last year, when Sir Richard Redmayne felt constrained to retire owing to his Government position. He has now consented to hold the post for another twelve months. Mr. Edgar Taylor is an able administrator and genial presiding officer. The fact that he is far from being a man of leisure makes the debt owing to him by members all the more real.

Dolcoath's Profits and Royalties.

If tin were a metal pressingly required in warfare, the Government would take control of the Cornish mines, and then the companies might have one of their grievances redressed, that is to say, some equitable basis would be settled for the royalties paid to the owners of the mineral rights. The directors and shareholders of Dolcoath have sat helpless in this matter from time immemorial. Owing to the decrease in the yield per ton and the greater depth of the workings, the position in this matter has recently become rapidly worse. The time is opportune for examining the financial aspect of these royalties as it affects the lord and the shareholder. The present company has been in existence for nearly twenty-two years, having been formed on June 17, 1895. The capital is £350,000, in £1 shares, of which 188,000 were allotted fully paid to the vendors and 162,000 subscribed in cash at par. From the commencement of the company until December 31 last, 1,973,140 long tons of ore was raised, and the yield of black tin was 38,080 tons, which sold for £3,088,677. The yield per ton was 43¼ lb. or 1·93%, falling gradually from 79 lb. in 1895 to 30 lb. in 1916, and the receipts per ton averaged 31s. 3d. The aggregate working costs were £2,242,098, or 22s. 8d. per ton of ore, and the lord's royalties totalled £179,440, or 1s. 9d. per ton. Out of the company's gross profit, £210,786 was written off for plant and development, and £442,701 was distributed as dividend, being at the rate of 126%, or an average of 5⅝% per year. No shareholder could possibly consider such a return as profitable, especially seeing that the present market value of the £1 share is only eight shillings. Comparing dividends with royalties, we find that the shareholders received £442,701 and the mineral lord £179,444. If the company had not been hampered by this high royalty, and had been paying instead a ground rent of £1,000 per year, the shareholders could have received £600,000 as dividends. Under such circumstances the shares would have just come within the requirements of profitableness. This is the position with regard to royalties spread over twenty-two years. If we take the years 1915 and 1916, we find that during that period the company's gross profit, before allowance for depreciation, was £21,429, out of which £14,874 went as royalties. The position is of course utterly ridiculous and insufferable. Dolcoath was sufficiently oppressed in its palmy, or shall we say, glorious, days. Now it is in much the same position as many less fortunate mines in Cornwall, whose royalties steadily remain in the cost sheet, but never have the chance of appearing in a profit and loss account.

Qualifications as Mine Manager.

The oft-debated subject of the qualifications, experience, and training requisite for the post of manager of a mine cropped up recently at a meeting of the South African Institution of Engineers. The Union of South Africa follows the practice in connection with coal mining in Great Britain, and sees that nobody becomes a mine manager without having passed certain examinations and having had a considerable amount of experience underground. The minimum time of previous underground work is fixed at five years. At the meeting in question, Mr. S. E. Boult introduced a resolution recommending the Government to reduce the five years to two years and a half, in the case of mechanical engineers associated with mining operations. Such a resolution would never have stood a chance at a meeting of the Chemical, Metallurgical, and Mining Society, for the opportunities of promotion for the mining engineer are already few enough, and any proposal that involved a "dilution," as it is called nowadays, would not be acceptable. A more beneficent reception was expected by Mr. Boult at the Institution of Engineers, but he was disappointed and he had to withdraw his resolution. There was, however, some useful discussion, and the time occupied at the meeting was not wasted.

It seems to us that no hard and fast rule can be laid down as to the necessary qualifications of a mine manager, for at different properties and in different mining regions the problems confronting him vary widely. Similar variations exist according to the stage of development, ranging all the way from the prospect and the vein extremely difficult to follow, to the lode or reef the nature and extent of which is perfectly well understood. In general terms it may be said that for the development of prospects and for following erratic ore deposits we should seek a mining engineer who has paid attention by study and experience to the problems of economic geology. On the other hand, where the deposit is of large extent, as at the porphyry coppers, the Treadwell mines, or the Rand, we should pick a mining engineer who has an intimate acquaintance with mechanical engineering. We should never give the management of any mine to a geologist pure and simple, and if he wanted to qualify for the position of manager we should expect him to take the full preparation required of a mining engineer. On the other hand a mechanical engineer who has become practically acquainted with mines would often prove to be the best man to take the responsibility at properties with large well-defined ore deposits. Mr. Boult's 2½ years underground work would surely qualify the mechanical engineer for the position ; in fact a further curtailment of the probationary period would more often than not be justified.

In the future, large orebodies and also orebodies at depth will be brought into requisition for the supply of the necessary metals, and, especially in the case of deep deposits, the services of the mechanical engineer will become more necessary than ever. As regards alluvial mining, the problems of the bucket dredge are largely those of the mechanical engineer. And it is not only in these special or extreme cases that mechanical knowledge is desirable, for in all branches of mining the lack of it leads to conservatism and hesitation in mining and metallurgical practice. Very few mine managers feel competent to judge for themselves of the value of a new rock-drill or of a new system of winding. Thus the inventor or introducer of new ideas finds the obstacle of prejudice born of ignorance in his path. Then again, the design of plant for a mine is often handed over in its entirety to a firm of makers of machinery, who not unnaturally draw on their own stock or specialties, with the result that the equipment does not necessarily meet the particular requirements of the mine. These are only two instances of the disadvantages following the lack of mechanical knowledge on the part of the mine manager.

In offering these few remarks, we have purposely confined ourselves within narrow limits so that our point shall not be lost. But it is clear that neither geological nor mechanical knowledge may be the deciding factor in the distribution of appointments. At a big property it may be possible to retain the services of an expert geologist and a mechanical engineer, and in that case the general manager is chosen rather for his administrative ability and his capacity for choosing and handling men. Neither have we touched on the requirements with regard to metallurgical knowledge that are desirable in the mine manager, though much could be said on this point. But we do not want to get on to these side tracks, so we conclude by repeating our thesis that mechanical engineering will become more and more the ruling factor in the success of mining operations.

Fuel Economy.

The Government has taken control of the coal and mineral oil industries of this country with the object of regulating the output, distribution, and consumption, rearranging labour supplies, and stabilizing the prices. This is part of the war policy. Concurrently the Government has appointed a Commission on fuel economy, and the control will facilitate the application of the Commission's recommendations. There are many apostles of fuel economy in the land, some of them merely defenders of their present system of burning coal, others the exponents of particular applications of fuel, and still others who see that certain fuels and constituents or by-products of fuel are too valuable to burn. The points of view of these various writers and speakers extend all the way from immediate selfish interest to a large-minded consideration of the world's future requirements. We believe that Government control will be able to secure an even balance among the various interests and inaugurate a settled policy of conservation. Not only so, but steps can be taken to prohibit the use of any method of using fuel that is detrimental to the health of the individual or the community.

In the early days of steam-raising for power purposes, coal was burnt in furnaces of the Cornish and Lancashire type. These have the disadvantage of forming much smoke, which is not only uneconomical but also makes a blot on the landscape. Improvements ensuring better combustion have been introduced by the use of mechanical stokers, and greater rapidity in steam-raising has been secured by the use of water-tube and locomotive boilers. The water-tube boiler is at present the favourite both for good combustion and for flexibility of application. Another method for employing the heat of coal was provided by the gas engine. The illuminating gas from the town mains may be utilized for this purpose, but this source is extravagant. The introduction of producer gas and water-gas opened a large field for application of the internal combustion engine, and, later, the saving of the gases at coke-ovens and blast-furnaces extended the opportunities. These by-product gases have also been advantageously applied in steam-raising furnaces, by themselves or as an adjunct to coal-firing. Then again, gas is being used for producing an intense heat by judicious mixture with air or oxygen, and by means of the principle known as "surface combustion." The most recent method of applying coal for power production is by injecting it in powdered form into the furnace together with a regulated supply of air. We believe that this method will prove of great economic importance in the future.

The use of wood as a fuel amounts to a crime in many places, and steps are being properly taken in most countries to control the destruction of timber. Suffice it to say that miners only use it in default of other fuels. Wood can be used for direct steam-raising, for the production of charcoal, and for the manufacture of producer gas, and the by-products in the last-named process are of similar value to those obtained in gas and coke manufacture.

Petroleum and shale-oil are not proportionally so valuable as fuels as coal, partly because the world's resources are far smaller, and partly because only portions of the raw material are burnt as fuel. The lighter fractions, constituting a small percentage of the total, and known as petrol in this country and gasoline in America, are in demand for driving the smaller and travelling types of gas engine. The middle products are paraffin or kerosene, and lubricating oils. Wax for candle-making and vaseline are other products. The most important constituent from the fuel point of view is the heavy residual oil, which can be used both in the Diesel type of internal combustion engine and in the steam-raising furnace. By far the largest proportion of heavy oil is used for steam-raising either by itself or in conjunction with coal, and in all probability this proportion will persist. Occurring with petroleum is natural gas, composed of the higher constituents that are volatile at ordinary pressures and temperatures. Another method of utilizing petroleum for power purposes consists of "cracking" the heavier constituents into petrol and gas. This method is the subject of much research, and its importance will in all probability increase.

Fuels are, however, not only used for power purposes, but also for illumination and heating. Of illuminating gas produced from coal all we need say here is that the tendency nowadays is to limit the light-giving constituents, and to make it more in the nature of a heating gas suitable for use with the thorium mantle. Fuel for heating may be divided into the domestic and industrial. The domestic fireplace is the greatest waster of heat that could be devised, but it holds its own against central systems of heating. The wastefulness of the one and the unpleasantness of the other could both be avoided by the use of a stove similar to the anthracite stove of America, but with an open front. These are to be seen in the Bank of England, and Government control could facilitate their adoption. The closed-range cooking stove is another abomination to the fuel economist, and was apparently designed as a monument of inefficiency by a ring of colliery proprietors keen on expanding their output.

In burning fuel for heating purposes in the industries it is seldom that raw coal is employed. A notable exception is the burning of anthracite for drying various materials, and the use of bituminous coal in the Scottish blast-furnaces. Coal is usually converted into more convenient forms of fuel such as coke and gas. These products are not only used for heating purposes, but also in chemical and metallurgical reactions. Moreover, coal is largely consumed not for the manufacture of other fuels but for the production of coal-tar derivatives, pitch, and ammonia, with coke as a by-product. When coal is distilled for the production of metallurgical coke, the gas, tar, ammonia, and pitch are recovered as by-products. At the present time the position with regard to coal-tar derivatives is abnormal, for the demand for benzol, toluol, and phenol in high explosive manufacture is immense. In ordinary times, the demand for benzol as a substitute for petrol will revive and increase, but its manufacture can never be the prime object of the carbonization of coal, because the amount produced per ton of coal is comparatively small. Probably the coke produced would be the deciding factor, for it is obvious that the carbonizer will not load himself with unsaleable coke. The problem of coke as a by-product is always with us. Much of it is difficult to sell, and occasionally it can be had at the cost of cartage. At the present time the stock at gas works is accumulating. It is only produced as a by-product when other products pay for the carbonization of the coal. Efforts have been made to modify the coke position by carbonizing at lower temperatures and producing a coke that will burn freely in the open grate, but as this coke is friable success has not yet been attained by these processes. From the broad point of view of the conservation of the world's resources, the production of an excess of coke constitutes in fact a waste of the reserves of fuel.

Reference may fittingly be made to two other sources of power, alcohol and water. Alcohol is an alternative for petrol and benzol in the light internal-combustion engine. As its manufacture consumes materials that are useful as food, it should be ruled out, at any rate at present. As regards water-power, its use should be recommended wherever possible with the object of conserving the resources of coal and wood. Government control could encourage or even enforce the harnessing of the water of innumerable rivers and high-level lakes in Scotland. These lakes and rivers are mostly situated in rocky and barren regions near seaboard, usually monopolized by wealthy sportsmen, who can afford to pay fabulous rents and so keep the pioneer of industry from launching congenial schemes. In Ireland, also, great benefits would accrue from the establishment of hydro-electric stations on the big rivers such as the Shannon and Erne.

Many economic questions will come before the Commission. One will be the utilization of heat at present usually wasted. In metallurgical practice, numerous examples of this waste can be quoted, with the qualification, however, that modern methods remedy this defect. For instance, the hot gases of reverberatory and open-hearth furnaces can be used for steam-raising, as can also the gases from zinc smelters. Another problem to be discussed is the distribution of power, in connection with which it is desirable to investigate whether it is cheaper to carry the coal to a number of independent power plants or to burn it at the pit's mouth and distribute the power electrically. The enormous consumption of coal in high-speed steamers also demands the curbing influence of Government control. Finally the relative claims of the steam turbine and the gas engine must be studied.

For ourselves, we believe that the steam turbine, including the low-pressure turbine, provides the most efficient method of utilizing fuel and gives the most flexible power. The system of gasification of coal, recovering by-products, and the employment of internal-combustion engines stands no chance in comparison, for the engines are not so easily superintended or so flexible, the demand for tar by-products is not unlimited in normal times, and the production of coke would become unwieldy. We look to the new Commission on Fuel Economy for the effective tackling of all these problems.

Tin Assays.

As our readers are aware, the Institution of Mining and Metallurgy recently appointed a committee to study the treatment of tin ores in the aspects both of improving concentration practice and of seeking for alternative methods of extraction. We ourselves evinced the same interest in the problem by publishing in our issue of July last a paper by Dr. O. J. Stannard on chemical methods of tin extraction. An equally important subject for research is the wet assay for tin, for it is obvious that the close study of tin-ore treatment is impossible unless the methods of assay for the various products are reliable. In the old days the vanning-shovel assay was considered good enough for the miner, and for two reasons. In the first place it gave results approximately the same as could be expected in the dressing plant, and second the chemical methods were not considered reliable. During the last ten years the wet assay has been greatly improved, particularly by Pearce, Beringer, and Hutchin. Not only have better methods been introduced for bringing the tin into solution as stannous chloride, but the details of subsequent estimation have been closely studied. The late J. J. Beringer was an indefatigable investigator, and his work at Camborne ranks high. His mantle has worthily fallen on Mr. H. W. Hutchin, his collaborator, and the research continues with characteristic patience and earnestness. The value of Mr. Hutchin's work may be gauged by his paper presented at the meeting of the Institution of Mining and Metallurgy held on February 15. Though many valuable papers on tin assay and tin dressing have been published by the Institution, it is fitting to consider Mr. Hutchin's present contribution as the first fruits of the recent new departure of the Institution in the systematic study of tin. In his paper Mr. Hutchin examines closely many possible sources of error, and gives details of his researches and his conclusions. We do not attempt either in this column or in our Mining Digest to quote his views and results. The paper must be read in full, and the points appreciated by the skilled assayer.

The discussion at the meeting was full of interest. Many of the remarks made were, for various reasons, not intended for publication, and a full report will therefore not appear in the Transactions. For this reason we do not give the names of the speakers who brought forward two points on which we desire to touch. The first of these is in connection with the contamination of the sample by the dilution with material abraded from the mortars or other apparatus used in crushing. Mr. Hutchin gave in his paper his experience in this direction, and in following the argument one of the speakers gave it as his opinion that a greater opportunity for error arose from the escape of part of the sample as dust during crushing. With the pestle and mortar the chance of escape is not so great as with the bucking board or iron plate, but nevertheless the amount lost is considerable. The various constituents of the ore or concentrate have different tendencies to dust, so that the assay of the crushed sample will not be the same as that of the sample before it was crushed. The speaker gave an instance of the influence of these losses culled from his experience with copper ores. He had a bulk sample weighing 15 tons, and after passing it through crushing machines, making screen analyses, etc., he found that the total weight of his various products was quite 5% short of the original weight, the remainder having escaped as dust. He collected samples of dust that had settled on the machines and on parts of the building, and found that they assayed 11% of copper as compared with 2·3% for the bulk sample. These facts have obviously a bearing on the question of error arising from dusting.

The other point raised referred to the ethics of assaying, as affected by the respective interests of the seller and buyer of the ore. Mr. Hutchin had referred to this matter and had shown that the buyer's assay was usually from 0·3 to 0·4% less than that of the seller. One of the speakers, in commenting on this fact, expressed a certain amount of sympathy with a seller's assayer who met the buyer's guile by returning his results at a correspondingly higher figure. It was generally felt, however, that "doing evil that good may come" is not in accordance with professional ethics, and that such a thing as commercial influence should find no place in dissertations on accuracy in assaying. In fact, the Institution should take no cognizance of "cooking," but confine itself to strict science.

In concluding our review of the evening's events, we ought to say that the investigations described by Mr. Hutchin were made in connection with the low-grade concentrate averaging 20% tin, which is nowadays a product acceptable to certain smelters operating new processes the nature of which are not divulged. Mr. Hutchin promises further papers recounting his experience with low-grade ore and tailing.

REVIEW OF MINING

Introductory.—The political and economic position of this country becomes more straitened every day and new business in mining is greatly restricted. The submarine menace is still acute, though the Navy maintains the stoutness of heart that denotes confidence. The subscription to the War Loan exceeded the most sanguine expectations of either the Government or the City financiers. The American attitude with regard to Germany's actions continues to be rather moral than physical. In the metal markets, copper has shown a tendency to advance again, and tin has once more been over the £200 mark, while the quotation of quicksilver has become "nominal." Our days promise to be brightened by the re-argument of the Globe & Phœnix case before the Court of Appeal. Of new discoveries of ore deposits, that of Flin Flon in Manitoba appears to be of considerable importance and already large bodies have been proved.

Transvaal.—From the year 1884 to the end of 1916, the total output of gold in the Transvaal has been worth £514,908,000, and £123,588,000 has been distributed as dividends.

The Consolidated Mines Selection Company is reaping the reward of judicious enterprise. By this time shareholders will have forgotten the lean years from 1906 to 1911, and the writing down, in the latter year, of the shares from £1 to 10s. The success of the Brakpan in the Far East Rand has been not only a notable public event but a big asset to the controllers and to the shareholders. The Springs mine, under the same control, is on the threshold of its career as a producer. The recent expansion by means of the Rand Selection Corporation, the participation in the Daggafontein flotation, and the acquisition of the South Brakpan ground are other indications of vitality on the part of this group. Consolidated Mines Selection has just declared a dividend at 22½% for the year 1916, as compared with 15% for 1915, and 5% during 1914 and 1913.

The new controllers of Randfontein Central, the Barnato group, have issued a cable reviewing the conditions at that mine. They criticize past practice in both mining and metallurgy. When the full report comes to hand, we shall be able to discuss details.

Rhodesia.—The output of gold during January was worth £296,113, as compared with £306,205 in December and £318,586 in January a year ago. The figure has not been below £300,000 since February 1915. The Globe & Phœnix has reverted to its average assay-value of ore treated, and reports £33,176 obtained from 6,252 tons of ore during January, as compared with £42,285 from 6,189 tons during December. Shamva shows a temporary decline in ore treated. Affairs at Bell Reef are discouraging, for the yield per ton has decreased lately, standing at only 19s. 6d. during January as compared with 35s. 7d. in August, and the loss per ton is now 14s. 1d.

Since Mr. Justice Eve delivered his celebrated judgment in favour of the Globe & Phœnix, Mr. G. R. Bonnard, the chairman of the Amalgamated Properties of Rhodesia, has had a rough time of it at the hands of conspirators and agitators, and he has temporarily retired from the board. Mr. H. Seymour Foster, the owner of a large block of Amalgamated shares, came to his rescue, and at a meeting of shareholders turned the tables on the agitators. Affairs having been straightened once more, the company has lodged an appeal. It is announced that Sir John Simon has been retained for the company.

Belgian Congo.—Shortly after the outbreak of war the Union Miniere du Hant Katanga found it impossible to hold shareholders meetings or distribute profits. The debenture holders in Tanganyika Concessions, the English company that holds about 40% interest in the Belgian company, had therefore to agree to a postponement of interest distribution until six months after the end of the war. At the recent meeting Mr. Robert Williams announced that two millions was awaiting distribution by the Union Miniere and that some suitable financial arrangement was being sought whereby the funds could be released. The debenture holders are now gratified to find that such an arrangement has been made, and that coupon 16, due January 1, 1915, is to be cashed forthwith.

West Africa.—The output of gold during January was worth £131,665, as compared with £146,409 in December and £140,579 a year ago. The figures for December were above the average, as they contained the year's returns from Broomassie re-treatment of tailing. The Abbontiakoon treated ore of lower grade during January, the average yield being 29s. 8d. per ton as compared with an average of 38s. during the previous six months. On the other hand, the returns from Prestea Block A show a distinct revival.

The directors of the Broomassie Mines have decided to wind up the company. The reserves were exhausted eighteen months ago, and since then the work has been confined to the treatment of residues by tributers. This contract is now terminated, so the company goes into litigation. The mine has yielded a large amount of rich ore, but little profit accrued to shareholders, owing to high costs in a difficultly accessible part of West Africa.

Australasia. — A number of wolfram properties, of which Leisner's is the most important, at Wolfram Camp, North Queensland, have been acquired by the Thermo-Electric Ore Reduction Corporation, a company producing ferro-alloys at Luton, Bedfordshire. The power plant at the Giew mine, Cornwall, has been purchased, and will be shipped to Queensland. The mining and metallurgical plant at Giew is now operated by current purchased from the Hayle Electric Supply Company. F. C. Cann, lately manager at Giew, is proceeding to Queensland.

Negotiations have at last been completed whereby the Queensland Government will build the railway connecting the Mount Oxide group of copper mines with the Cloncurry railway system. It is hoped to complete the railway this year. As we recorded recently, the Mount Oxide company is now in the control of the Mount Elliott company, and the high-grade ore developed at those mines is a most important asset.

The Bullfinch Proprietary is the victim of one of the many absurdities of the British income-tax law. The particular absurdity to which we refer is the calculation of the tax due in any particular year on the basis of the average of the three previous years. After payment of the Australian tax and making provision for the British tax, there is no margin for a final dividend left out of the profits of the year for the Bullfinch shareholders.

A company has been registered at Somerset House called the Pilbara Copper Fields, Ltd., with a capital of £5,000 in 5s. shares, the object being to handle the Whim Well copper property in the north of West Australia, which is now in the hands of the debenture holders of the Whim Well Copper Mines Limited.

A new source of wolfram has been discovered recently at Hatch's Creek, in the Northern Territory. According to an official report by Mr. T. G. Oliver, wolfram deposits have been proved over eight square miles, and a large area of similar country remains to be prospected. A number of veins of varying thickness have been found. Already about 60 tons of concentrate has been produced.

In consequence of shortage of labour and difficulties in procuring supplies and stores, the directors of the Waihi Gold Mining Company have decided to suspend exploration and development below the 11th, or 1,300 ft. level, and to devote all available labour to the maintenance of the gold output. The report for the year 1916 is nearly due, and when the figures for reserve are published, the actual position will be better understood. A year ago, the reserve was estimated at 806,052 tons, and in addition 673,896 tons in pillars, etc. This reserve, exclusive of pillars, is sufficient for four years supply at the present rate of extraction. The 12th level, at 1,447 ft., was commenced a year ago. It will be remembered that this mine, one of the great gold mines of the world, was highly profitable in the upper levels, and that it provides an example of the impoverishment in depth of gold deposited in Tertiary times.

Cornwall. — Reviews of the reports of East Pool, Tincroft, and Dolcoath appear in the Mining Digest, and our Camborne correspondent also deals with these and other matters. We draw attention to the longitudinal section of the Dolcoath workings appearing on page 179. The developments at East Pool constitute the most important event in Cornwall for many years; we hope to be able to publish an account of conditions and prospects at this mine in our next issue.

Malay. — Last month we recorded that No. 1 dredge of the Deebook Dredging Co., at Renong, Siam, had been sunk, just after an extensive overhaul. We also noted that much of the ground had been proved unpayable. Arrangements have since been made with the Ronpibon Tin Company, whereby the latter will raise and rehabilitate the dredge at its own cost, and use it for treating 90 acres of its ground adjoining. The Deebook stands a chance of making a good profit out of returns by this transfer of the dredge.

Canada.—The Tyee Copper Company has had a disappointing record. The properties, on Vancouver Island, were introduced in England by the late Clermont Livingston, and an attempt to float them was made by the late Nicol Brown in 1898, as the Chemainus Mining & Smelting Co. A year afterward the present company was formed, with Mr. W. Pellew-Harvey as consulting engineer. Subsequently Mr. W. H. Trewartha-James was resident director for some time. The ore deposit was, however, limited, and the founding of a permanent custom smelting business was attended with difficulties and not eventually successful. Arrangements were made last month to give an option on the property of the company to Mr. Seiberling, of the Goodyear Tyre & Rubber Co., of Akron, Ohio. This option extends to the end of 1920, and the total sum involved in $310,000. The deposit paid by the holder of the option is sufficient to discharge the mortgage on the property, £20,000, but the shareholders will not receive anything until the option is exercised.

In November last we printed an article on the gold-copper deposits recently discovered at Flin Flon and Schist lakes near The Pas, a station on the Canadian Northern and Hudson Bay Railway, and close to the boundary between Manitoba and Saskatchewan. Two companies have been actively engaged in development, and their results are notable. The Great Sulphide Co. is working on the shore at Flin Flon lake. Trenching across the lode for a length of 1,700 ft. has given a sampling value of $10 per ton in gold, silver, and copper, the latter being estimated at $1\frac{1}{4}$%. At one point the lode is 300 ft. wide. Diamond-drilling has indicated the presence of 3,000,000 tons of ore. The property on Schist lake is worked by the Mandy Mining Co., a subsidiary of the Tonopah Mining Co. of Nevada. It is reported that diamond-drilling has indicated 110,000 tons averaging 22% copper, with a small amount of gold.

The output of gold in British Columbia during 1916 was $5,390,000, comparing with $5,937,934 during 1915. The total value of the mineral output is given at $42,971,000 as compared with $29,447,508 the year before, but how much of the increase is due to the rise in the prices of silver, copper, lead, and zinc, and how much, if any, to an increase in the amount produced, is not clear. We wish the authorities would tell the whole story.

United States.— In spite of the strike a year ago, the Arizona Copper Company is able to present an excellent report for the year ended September 30 last. Though the smelters were only operating eight months out of twelve, the output was 15,230 long tons, as compared with 16,700 tons for the previous period of $11\frac{1}{3}$ months. These figures give an idea of the recent expansion in the scale of operations. The gross profit was nearly a million pounds. The ordinary shareholders received an 80% dividend, and large sums were allocated to the redemption of debentures, which were created a few years ago to provide funds for the new smelting plant. The headquarters of this company are in Edinburgh, and the board of directors exhibit the characteristic Scottish prudence and caution.

Mexico.—Conditions at the Santa Gertrudis silver mine continue to be unsatisfactory on account of the shortness of cyanide. During the quarter ended December 31 last, the treatment plant was idle for 36 days for this reason, and during the remainder of the period the operations were on a restricted scale. Development is being severely restricted. Wages are 25% higher than five years ago. The profit at the mines for the three months was only £3,336. It is only the high price of silver that keeps things going at all.

A dividend from a Mexican mining company is a rara avis in these days. The Mexico Mines of El Oro has done so well since the resumption of milling in August last that it is possible to distribute 7s. per £1 share free of tax. The reserve of ore is estimated at just over 500,000 tons, averaging 10 dwt. gold and 6 oz. silver per ton.

Russia. — The output of platinum continues to decrease in an alarming manner. The yield for 1916 is roughly estimated at 68,000 oz., as compared with 107,000 oz. in 1915, and 157,000 oz. in 1914. The fall is largely due to the workers having gone to the war, and also to the fact that it is next to impossible to keep the dredges in good repair.

The Russian Mining Corporation has issued a circular stating that negotiations are being made with a Russian financial group with the object of selling to the latter the interests of the corporation in the Altai Concessions. In this way it is expected that the necessary funds for developing the Zyrianovsk lead-zinc mine will be obtained. The corporation also reports that the Byelousovsk copper property, on the Zminogorsk Concession, has been prospected by diamond-drilling, and that the results obtained indicate the continuance of the orebody, averaging 20 ft. wide and 3 to 6·7% copper. Further prospecting of this orebody should be undertaken in order to show its extent.

The transfer of control of the Lena gold mines to Russia is proceeding rapidly. Lena Goldfields, Limited, the English company that used to hold the majority of shares in the Russian company, the Lenskoie, has recently sold 41,000 Lenskoie shares to Russian buyers at the price of 450 roubles per share. The buyers also have the option to take the balance of the Lena Goldfields unissued capital, 246,703 shares, at 32s. 6d. per share. Payment in both cases will be effected by instalments.

Spain.—The Linares Lead Mining Co., one of Messrs. John Taylor & Sons' group, and operating mines in the south of Spain, is to be liquidated, as there is no prospect of finding more ore in depth. Operations began in 1852, and for very many years excellent profits were made. We regret that this influential house is by force of circumstances withdrawing from this district, for Germany is seeking to secure extended control in Linares and La Carolina, as well as in Mexico, to replace its lost Australian lead supplies. At this juncture we may remind readers that we published an article on lead mining in south Spain by Mr. E. Mackay Heriot in our issue of May 1914.

Bolivia.—We recently recorded that Aramayo-Francke Mines, Limited, an English company operating tin, wolfram, and bismuth mines in Bolivia, desired to liquidate and to transfer the assets to a new company to be formed in Switzerland, the object being that the great bulk of shareholders, who are resident in Bolivia, should avoid the English income tax. This step was blocked by the Authorities under the Defence of the Realm Act. An alternative method for relieving the Bolivian shareholders has now been brought forward. Briefly, the Bolivian business of the company is to be vested in a local board in Bolivia, to the exclusion of the directors of the company, and to be independent of the general meetings of the company save those held in Bolivia. This arrangement follows the precedent of the Egyptian Hotels Co., and is somewhat similar to the case of Mexico Mines of El Oro, Limited, the office of which was removed to Paris where a majority of the directors resided. It would of course be preferable that the whole subject of taxation of foreign shareholders and of double taxation in two countries should be revised in a broad-minded way by the Government, instead of individual companies having to seek extraneous expedients for protecting the interests of their shareholders. The company's yearly report for the period ended May last shows a welcome improvement in the profits. As most of the information is usually given by the chairman at the meetings of shareholders, and not in the annual reports, we postpone detailed notice until next month. In the meantime we may briefly record that the year's profit was £167,557, as compared with only £3,504 the year before. That small profit was caused by the low price of tin, and the difficulty of shipping concentrates and of finding a market.

BUCKET-DREDGING FOR TIN

IN THE

FEDERATED MALAY STATES.

By HARRY D. GRIFFITHS, M.Inst.M.M., M.Inst.C.E.

(Concluded from page 86 in the February Issue).

Chapter IV.—The Design of the Dredges—The Pontoon—The Gantry Framing—The Ladder—The Buckets—The Ladder Rollers—The Screen—The Bottom Tumblers—The Top Tumbler—Other Points to be Considered—Conclusion.

THE DESIGN OF THE DREDGES.—Before any dredge was designed for the Federated Malay States several had already been at work on tin dredging in Siam, notably at the Tongkah Harbour Co., the Siamese Tin Syndicate, and the Renong Tin Dredging Ld. The first dredge of the Malayan Tin Dredging Co. Ld. was designed by Messrs. F. W. Payne & Co., of London and New Zealand (after careful investigation of local conditions by Mr. A. C. Perkins, the present general manager of that company), who had erected several dredges in Siam. It combined the best practice in that country with such alterations as were thought necessary to suit local conditions. The original results of that dredge did not entirely come up to expectations, many parts being found unsuitable or too weak. By experience and perseverance all the defects were remedied, and the machine eventually proved so successful that after four years of continuous work it is better and more efficient now than it has ever been, and its general design with slight alterations of details has been followed in the case of the two best and most efficient dredges in the country. The next designs, adopted notably by the Ipoh Tin, the Chenderiang, and Tekka-Taiping, followed too closely upon the Tongkah Harbour, or Australian, design, and are capable of important improvements.

The difference in the main design of these two classes of dredges will be apparent from the illustrations in Figures 4 and 5.

The design of the Australian dredges differs from the English designs in several essentials and details. The buckets are much smaller, of lighter and simpler construction and are close-connected; the screens are different, as will be shown further in detail, and are driven from their lower end; the ladders are of a different construction and more workmanlike; the steaming plant is heavy and cumbersome; the gantry framings are different and of simpler construction; the framing supporting the tables is very simple and free from the vexatious and unnecessary cross-bracing which characterizes some of the English dredges; the pontoons are shorter and wider, but the buoyancy hardly allows of an extension of the sluicing area. Their capacity is practically the same as that of the larger English type;

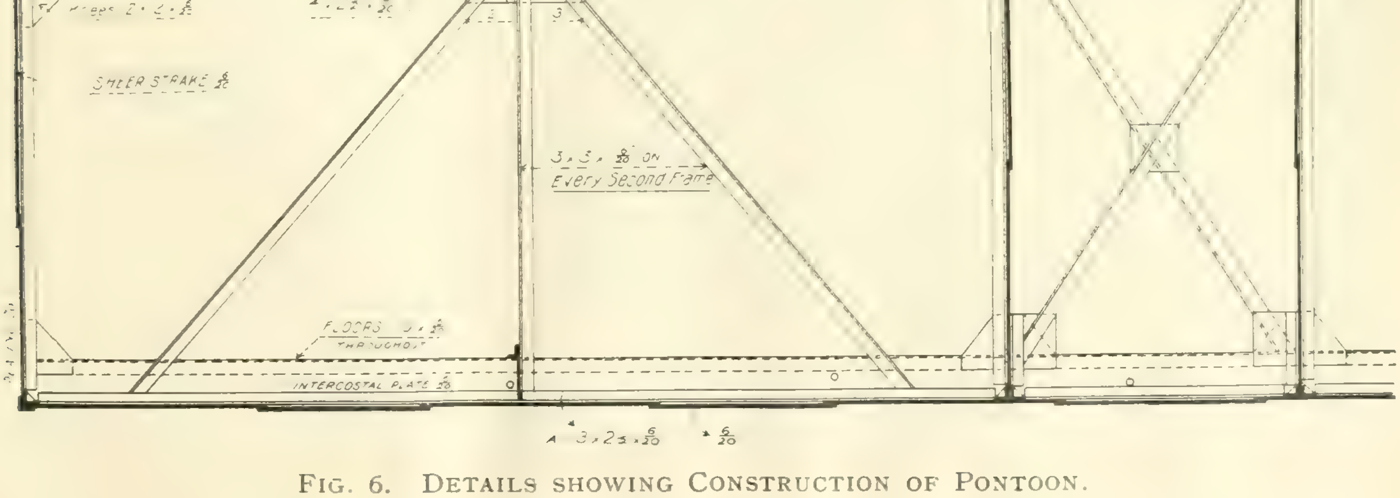


FIG. 6. DETAILS SHOWING CONSTRUCTION OF PONTOON.

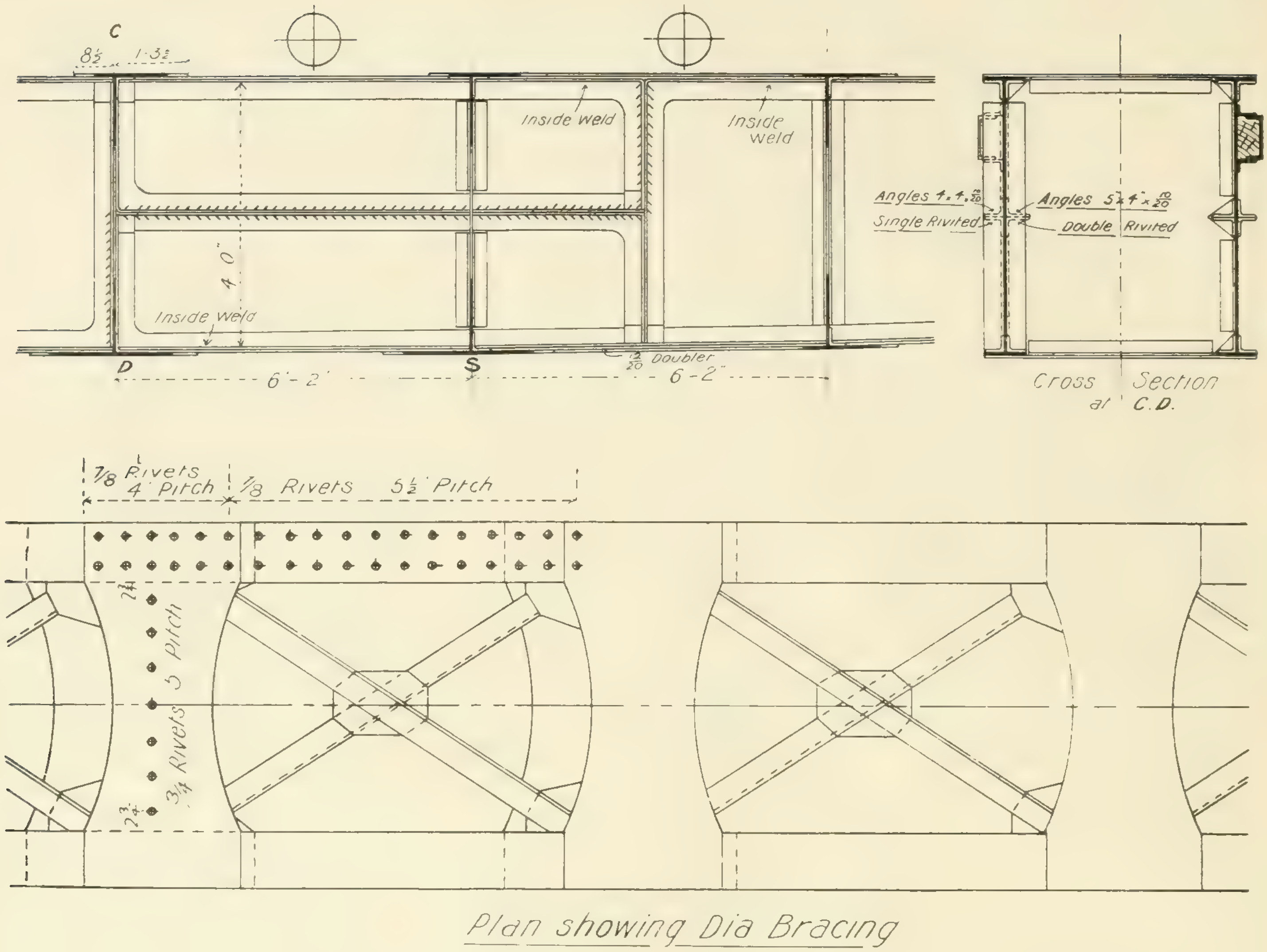


FIG. 7. TWO SKETCHES ILLUSTRATING LADDER DESIGN.

their horse power and fuel bills are similar; but they have not been called upon to face the hard digging which the English-built dredges are doing in the Kinta valley. For the class of ground they are working they are doing excellently, although there is not any doubt that an increase of sluicing area would be of advantage.

In all the dredges a notable fact is that many of the different girders are of unusual sizes. With a wider application of stock forms and sizes, some economy might probably be effected in primary cost, and a good deal of the machining could be done locally, much to the advantage of structural solidity. A large amount of cross-bracing could be dispensed with as being unneccessary, and this would allow a much clearer deck space. A good many spur wheels, pinions, etc., specially in connection with the winches, are made of cast steel, and could well be replaced by cast iron. The latter can be made locally, cheaply, and in a very short time. A good many such castings have already been replaced by local iron castings, which are answering their purpose equally well, resulting in lower cost and avoiding the necessity of keeping a large stock of imported material.

Speaking generally, the early dredges, balanced with water ballast, have too small an amount of buoyancy, but the latest type has a larger displacement, a higher freeboard, a greater margin of safety in the case of an accidental leak, and does away with water trimming. The water ballast being obtained from the paddocks, and being generally muddy, deposits quickly a large amount of slime in the tanks, which if allowed to accumulate reduces the buoyancy and necessitates troublesome cleaning-up.

It is of course impossible to design a dredge which will naturally keep perfectly trim under all conditions of work, as there are always on the pontoon constantly varying weights due to the position and immersion of the ladder, the quantity of drippings accumulating on it, the weight of fuel and feed-water on board, the load on the sluices, deck rubbish taken off the buckets and awaiting removal, etc.; but with a pontoon of wider dimensions and dis-

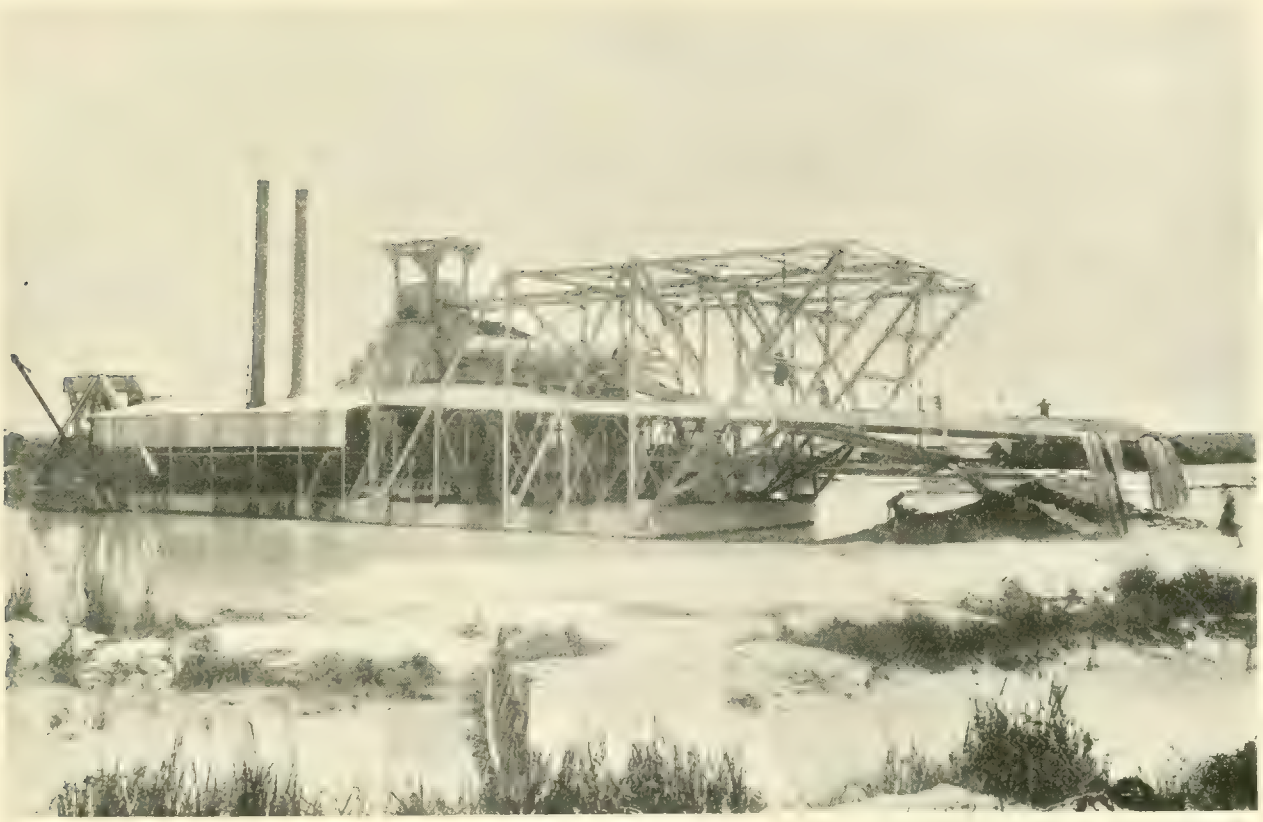


FIG. 4. THE IPOH DREDGE: DESIGNED BY MR. T. N. BLUCK, AND BUILT BY WERF-CONRAD.

FIG. 5. THE TRONOH DREDGE; DESIGNED BY MESSRS. F. W. PAYNE & CO., AND BUILT BY MR. ARTHUR R. BROWN.

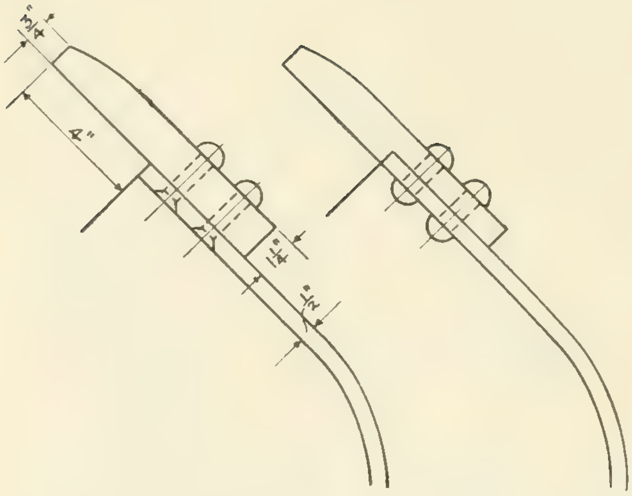


FIG. 8. FIG 9.
IMPROVED FORMS OF BUCKET LIP.

placement the effect of the variations becomes small and unimportant, and the inclination of the sluices remains fairly constant.

The steaming plant and machinery have in all cases been adequate, without, however, having a sufficient margin of power to allow of any additions in the shape of extra monitor pumps to break up clay in the screen, etc., as has been found necessary in at least one case.

The deck arrangements, disposition, and accessibility of all machinery and winches leave little to be desired, and permit of easy supervision, and the employment of the minimum number of deck hands.

THE PONTOON.—The pontoons are invariably made of steel plates and angles. They

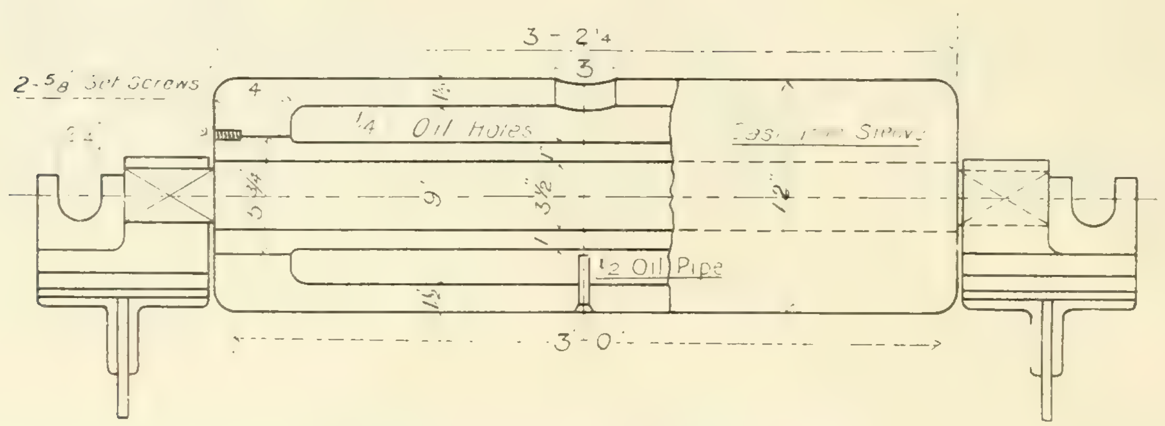


FIG. 10. A TYPE OF LADDER ROLLER.

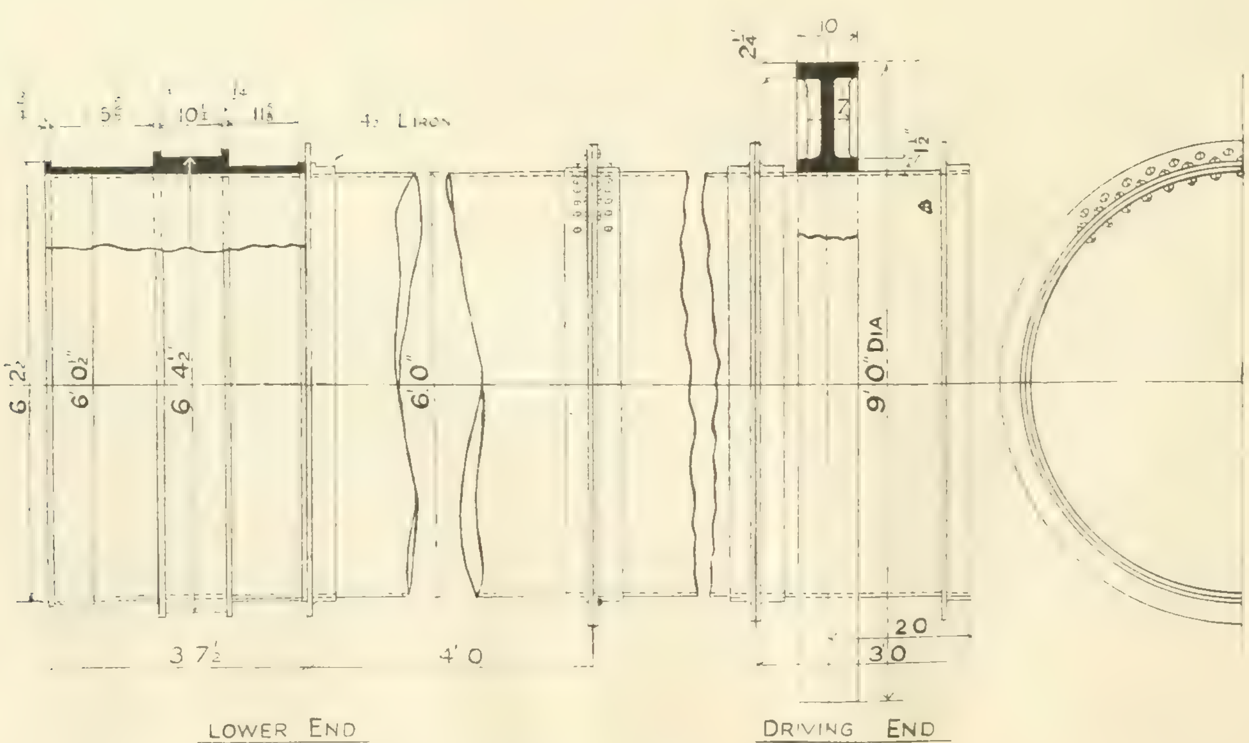


FIG. 11. AN EARLY DESIGN OF SCREEN.

are divided by a number of bulkheads into water-tight compartments, with all necessary stays, cross-bracing, etc. Details are shown in Figure 6. The hull plates are often all made of the same size, and punched from one template, so that they may be used in any position. The rivets are generally countersunk and flush on the outside, although no particular advantage seems to be secured, unless it is a saving on the cost of the rivets; this, however, is more than counterbalanced by the extra work of countersinking the plates. The hulls are generally fitted up and bolted before shipment in order to ensure a good fit, and to allow the marking and numbering of the different parts. Seams of tarred canvas are inserted before rivetting, and all the joints are carefully caulked.

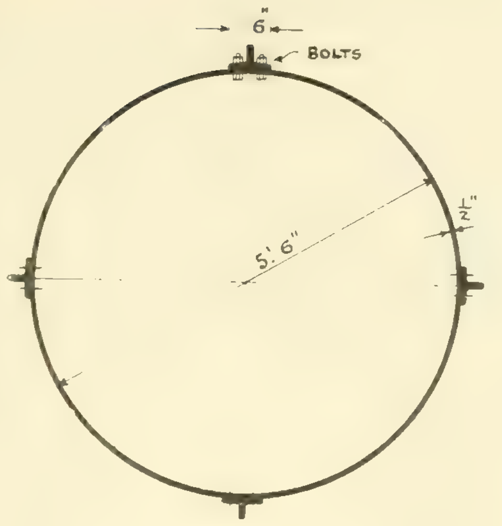


Fig. 12. Method of Stiffening Screens.

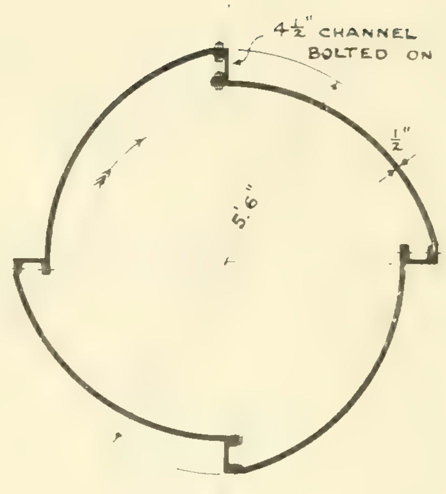


Fig. 13. Australian Design of Screen.

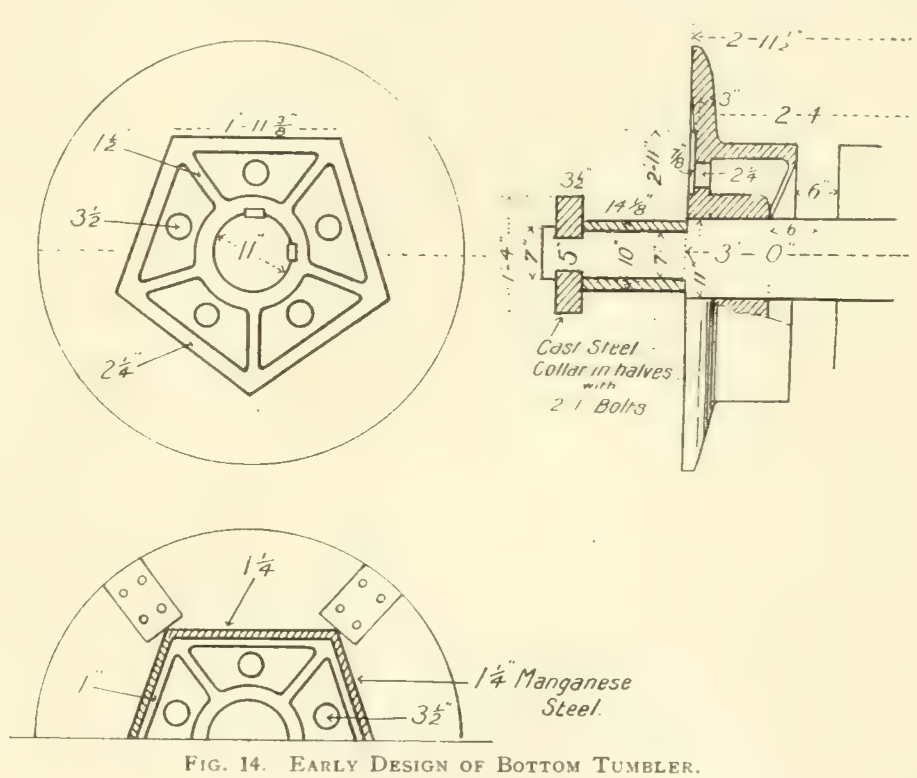


Fig. 14. Early Design of Bottom Tumbler.

Gantry Framing.—In the best design the main gantry and the forward or ladder gantry are connected together as one frame. This gives greater rigidity to the hull, strengthens the forward gantry and provides the supports necessary to lift up the buckets, etc. These are proving important points which are likely to be adopted in all new designs. The weakness of an independent forward gantry has been proved in several cases where hard digging takes place, and additional struts have been required. The Australian design differs from the above and appears very workmanlike. The forward gantry consists of a strong fish-bellied box girder resting on two square frames connected to the main framing. The girder projects over the forward end of the pontoon and carries the ladder pulley, as well as the forward anchorage lead pulley. A small crane, used for lifting tree stumps, boulders, etc., is generally placed either on the forward gantry or on the deck alongside, and may be worked by hand or by a winch. It is a most useful adjunct, which every dredge should possess, and if placed on the gantry itself it has a better range of action than if placed on deck. With the two gantries connected, it is easier to put in the side plates which protect the deck and machinery from splashes and bucket drippings.

The Ladder.—This has greatly exercised the ingenuity of the designers. It is subjected to a variety of strains, which are difficult to determine theoretically, and it must combine strength and rigidity in all directions beyond the usual allowances. Several of the early ladders, although apparently of adequate size and strength, have proved too weak, and one case of absolute collapse has been known.

The difficulty appears to be more connected with the side strain and sagging than in the longitudinal and transverse strains. Drag-bracing has not proved very effective, and it has the great disadvantage of offering a resting place for the bucket drippings, which gradually accumulate until the ladder is packed and has to sustain a great extra weight. The bays of the ladder should be free for the passage of drippings, and the strength should be great enough to dispense with any drag-bracing whatsoever. This has been achieved in the Australian design, which is simplicity itself, and which is answering well, being strong and rigid in all directions. A saving of weight in a ladder is not advisable, and rigidity appears essential. Figure 7 gives the main outlines of different designs.

THE BUCKETS.—The design of a durable bucket is an important item in a dredge. Although the work it is called upon to perform may apparently be light and may give reason for a light design, it is found in practice that too much strength cannot be given, and that a heavy bucket soon pays for its extra cost. The touching of a pinnacle, or cutting through a stump, often proves disastrous to a light bucket. All the English dredges have heavily built buckets, and were it not for that, many cases of failure would have been recorded. The cutting lips, which are of thick steel, rivetted to the outside of the body, generally take the damage on meeting with a hard obstacle, and save the body of the bucket if the latter is strong and substantial. They can easily be replaced, but if the body is not of sufficient strength it crumples and is not capable of being repaired. Even in light digging, without hard obstacles, the wear of the lips is very great owing to the ground being gritty, and if the lips are thick and wide, they efficiently protect the body from undue wear.

As the lips are rivetted on the outside and give no protection to the bucket against inside wear, the latter is often considerable, and soon renders the bucket unserviceable. It has therefore been suggested that the lips should be thickened so as to overlap the inside of the bucket as shown in Figs. 8 and 9, and that the rivets should not be countersunk on the inside. These two alterations would efficiently protect the body, and in addition, the rivet heads, by cutting channels and air spaces in the excavated ground, would allow the latter to be tipped more easily at the top tumbler. This has been found in practice to answer well.

The Australian buckets are much more simple in design, and very light, but so far they have not been called upon to work on tough clayey ground. Even in loose sandy ground they appear to wear rapidly.

The bucket links are generally substantial and of sufficient strength, allowing connecting pins of large diameter to be used. They are rivetted on to the base of the bucket, the same rivets holding the bucket body and base together. Their replacing is a tedious business, and it is thought that an improvement in the way of fixing them independently of the bucket rivets would be welcome.

LADDER ROLLERS.—These vary much in design. One is shown in Fig. 10. They all run loose on a fixed shaft, and are internally lubricated. The shafts or spindles are squared at the ends and dropped into square chairs, and as their top surface begins to wear unduly, they are lifted, given a turn, and dropped again into the chairs. The rollers were originally made of cast steel, but in most instances have been replaced by cast iron, which answers equally well, and can easily be obtained locally.

THE SCREEN.—The screens placed in the first dredges proved inadequate as regards strength, durability, capacity, and efficiency. The holes in the plates being too small, a great weight of material accumulated in the screen, and a large portion of the fine sands did not go through. The holes were enlarged,

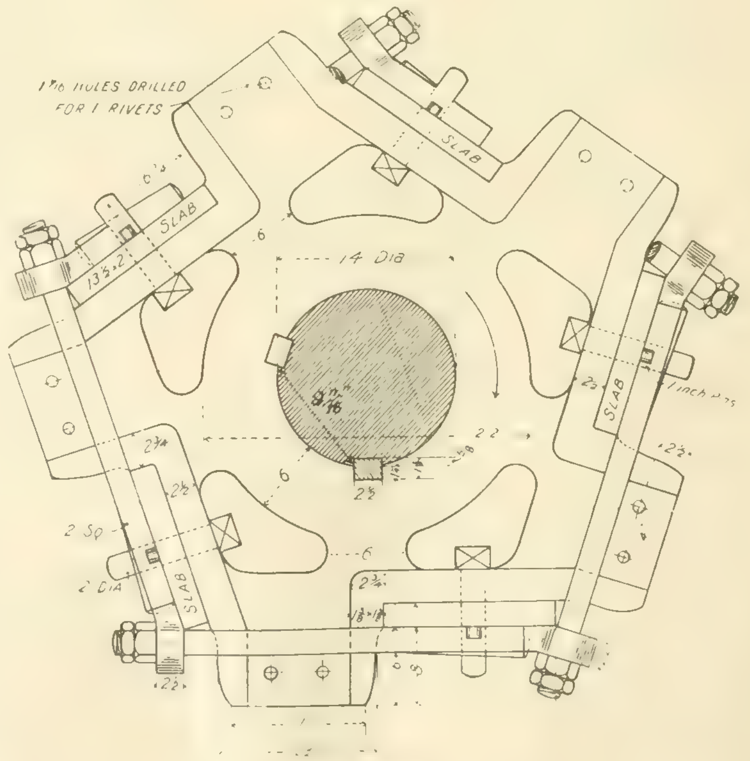


FIG. 16. SIDE VIEW AND

without, however, rendering the capacity adequate. The great weight of material soon told on the light construction, the flange rivets soon gave way, and an important loss of time in replacing sections took place. This will be apparent on glancing at Fig. 11, which shows one of the early designs. Greater stiffness of the screens was absolutely required, and that was obtained by adding longitudinal girders to take the strain instead of the section flanges. Such a screen is shown in Fig. 12. All parts of the screen are now bolted together instead of being rivetted, and this allows of much quicker work where more plates have to be replaced. One of the simplest and most efficient designs is shown in Fig. 13. It is adopted on the Australian dredges, and works satisfactorily. Rivets are also replaced by bolts. All screens are direct driven, except in one instance where chain driving is employed. The Australian screens are driven from their lower end, instead of the top end.

In spite of all improvements, the screen area is still too small in many of the dredges. It cannot, for obvious reasons, be enlarged on the present machines, but future designs for dredges having to work clayey sands should provide for an increase of at least 20 per cent.

Table XVIII. shows the amount of screen

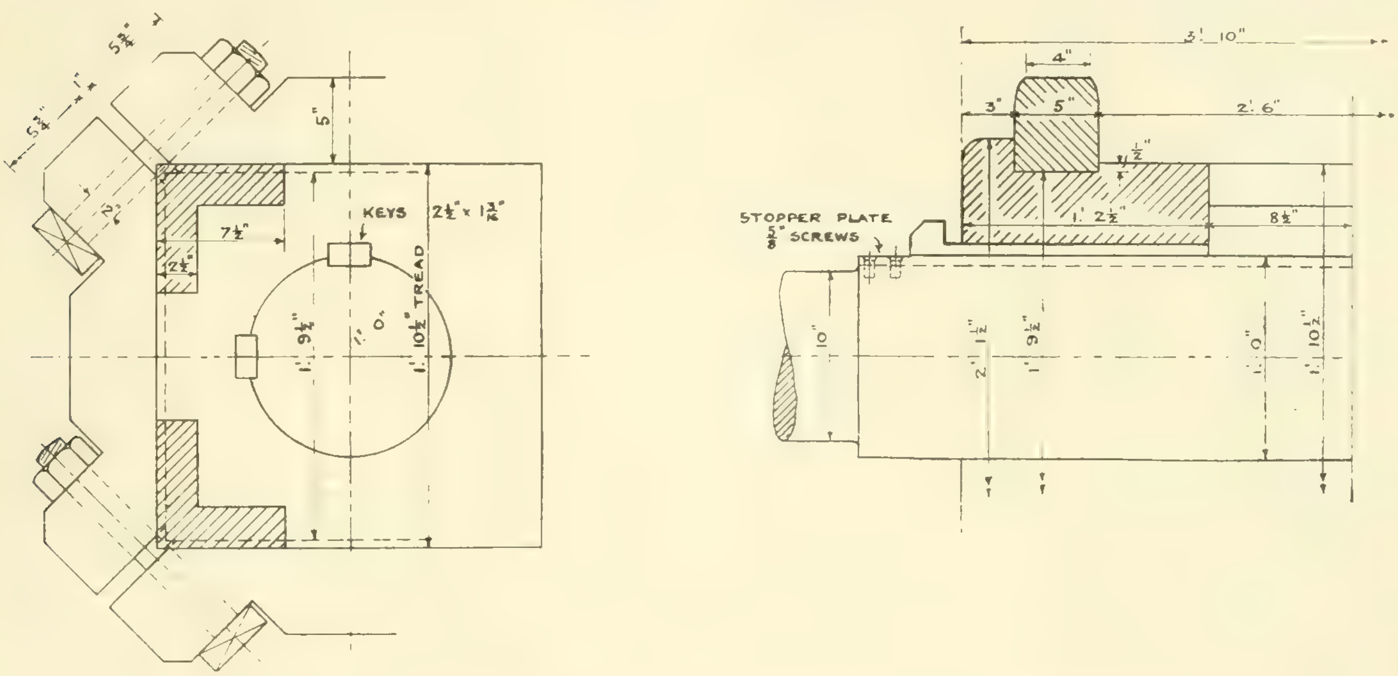
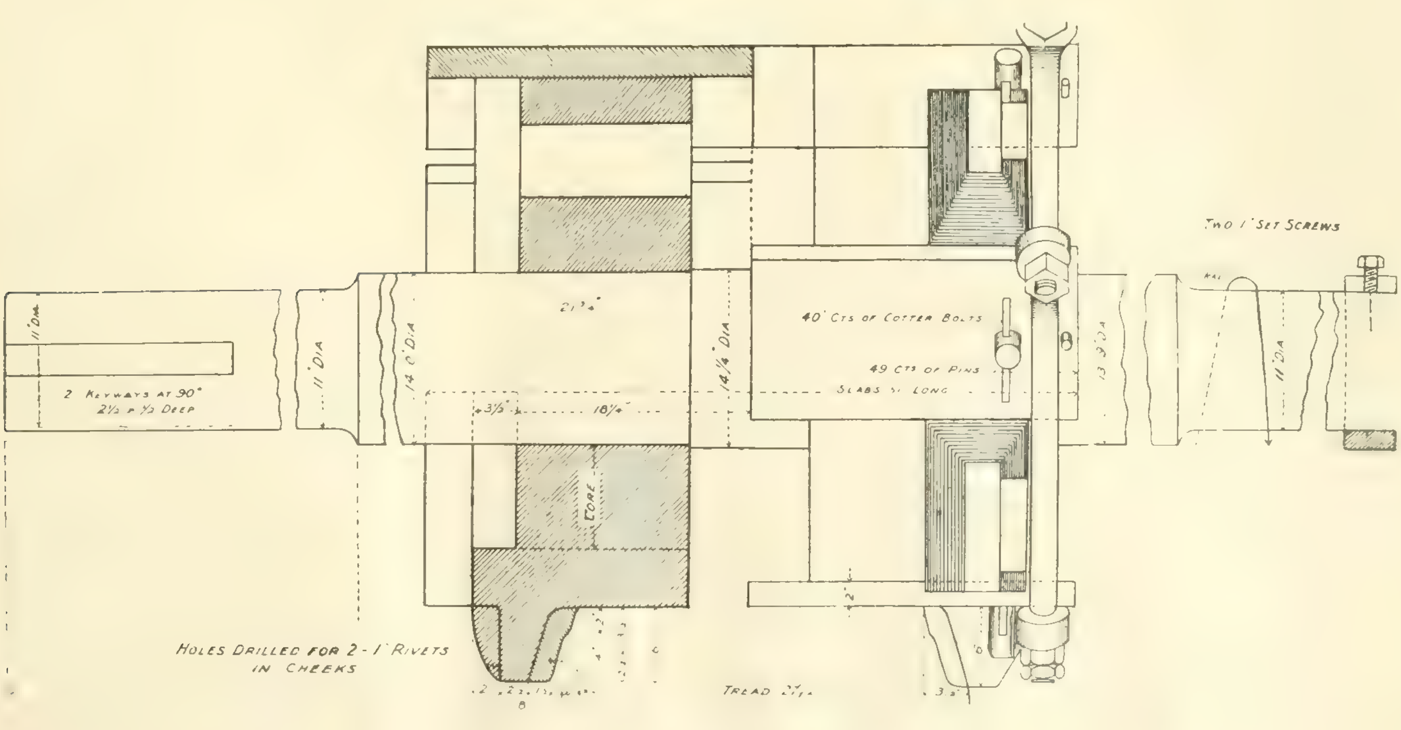


FIG. 15. ENGLISH TYPE OF TOP TUMBLER.



LONGITUDINAL SECTION OF AUSTRALIAN PATTERN OF TOP TUMBLER.

TABLE XVIII.—PARTICULARS OF SCREENS.

Dredge	Av. Cap. per hour c. y.	Inside diam.	Length ft.	Working Area sq. ft.	Rev. per Min.			Mean Hour Area	Mean Area per c. y.	Remarks
					Max.	Min.	Mean			
Ipoh Tin	107	5ft. 11in.	24	446·40	12	8	10	267,840	2,505	Hard clay
Tekka Taiping	153	5ft. 3in	25	412 25	12	8	10	247,350	1,606	Sand
Tronoh No. 2.	167	5ft. 6in.	24	414·67	12	8	10	248,802	1,490	Sandy clay
Malayan No. 4	160	5ft. 6in.	24	414·67	12	8	10	248,802	1,626	Clayey sand

area compared with average capacity in cubic yards per hour of some of the dredges. The area naturally varies with the speed of rotation of the screen, which, however, cannot exceed certain limits, and cannot easily be altered on the present machines.

BOTTOM TUMBLERS.— Generally speaking, these have given a lot of trouble, owing to faulty design, which did not provide for adjustable wearing plates. They originally consisted of two plain cast manganese steel flanges fixed on the shaft as shown in Figure 14. The tread on the drum wore out at a great rate and unevenly, and the constant rubbing of the link-pin heads on the flanges soon rendered the tumblers unserviceable. The defect was soon remedied by providing replaceable wear-plates on the drum, and also on the side flanges where the pin heads touch, as shown in the lower sketch in the figure. The shape and size of the wear plates vary according to the fancy of the operators, but they are answering well, and they save great expense as well as time. If these plates are well looked after, the bottom tumbler may last indefinitely, although the shaft has to be replaced when unduly worn out.

The bottom tumblers are generally five-sided in the case of open-link connection, and six-sided for close connected buckets.

TOP TUMBLER.—This is subject to an enormous strain and needs very careful designing. An ideal tumbler has not yet been designed, but Figs. 15 and 16 show respectively the best English and Australian patterns adopted. It is yet a moot point whether the drum wear-plates should extend along the whole face of the drum or only take the corners. The chief drawback of the former is found in the difficulty often encountered in taking them out for replacement.

OTHER POINTS TO BE CONSIDERED.—There are many other minor details on the dredge, which have had to be altered to suit the varying local conditions, but a description of which would be too lengthy. Practical work has demonstrated that table-area and screen-area could beneficially be increased; that service pumps should be placed inside the hull instead of on deck, and should number not less than two, one working against a head of about 60 feet to supply the sparge pipe, and the other a low-pressure pump to supply the riffles; that adjustable drop chutes instead of fixed ones are advisable; that increased table-area should be obtained by having two tiers of tables, rather than lengthen the existing ones; that the cross-bracing of the panel supporting the tables should be abolished, or arranged in such a way as to leave freedom of way on the decks; that a "save-all" arrangement at the end of the screen is advisable in many instances; that the air and vacuum pumps should be worked by an independent engine; and above all that the hull of the dredge should have an ample margin of displacement. Perfection has not been attained in any of the machines at work, but the latest designs leave very little to be desired, and it is fair to assume that the next dredges constructed for the Federated Malay States will embody all the improvements suggested by close upon four years of actual work, and will be highly efficient machines.

The costs of working per cubic yard will decrease considerably as the percentage of working hours increases. The latter is not yet what it should be, but is improving daily, and should soon reach an average all round of 85 per cent.

CONCLUSION.—The predominant note of those responsible for the bucket-dredging industry is the unbounded confidence in its success, and in its capacity to deal profitably with ground of as low a value as ¼ cattie per yard. Under these conditions the industry is capable of incalculable expansion for many years to come, whatever may be the fluctuations of the price of tin, and when conditions become normal, it should offer unique opportunities for the profitable investment of capital.

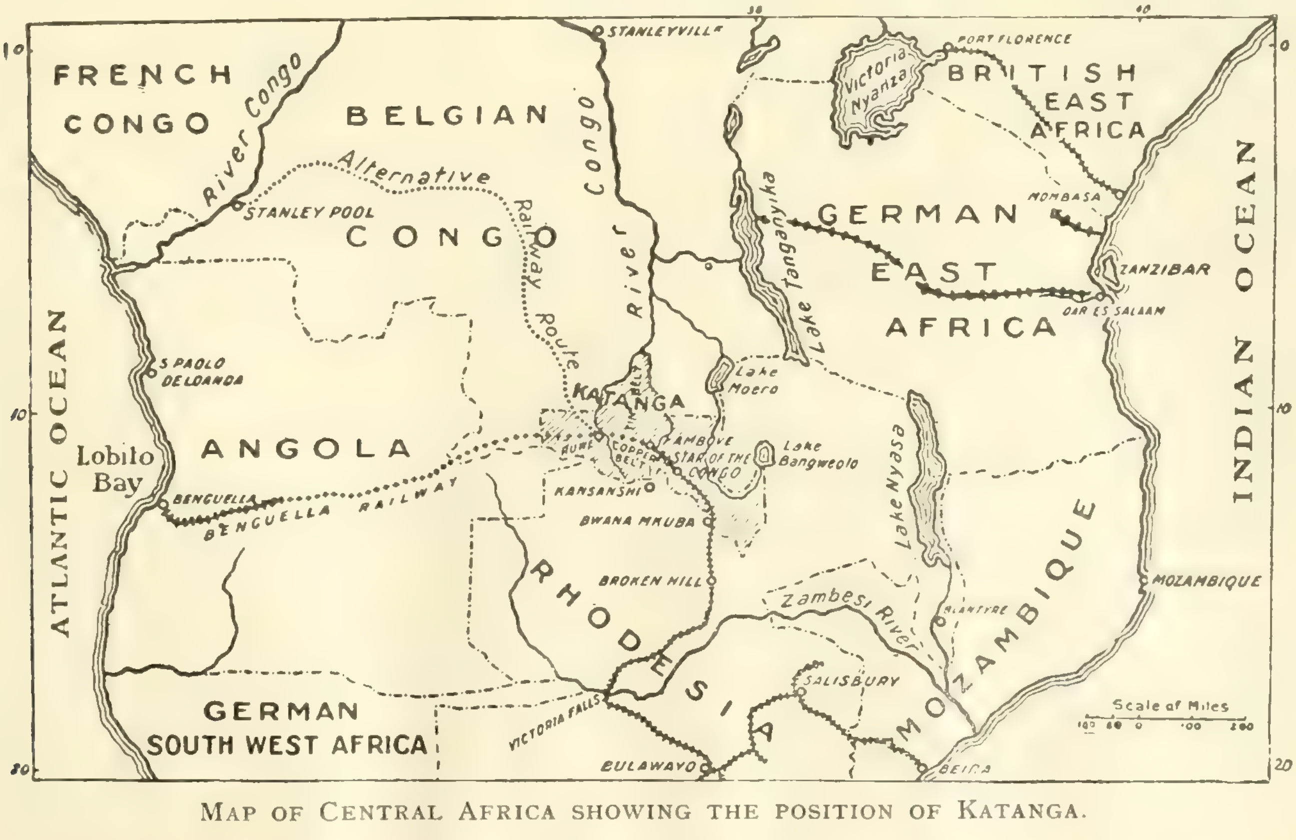
THE KATANGA COPPER DEPOSITS

By H. FOSTER BAIN.

The author gives an outline of the geology of the Katanga ore deposits, in the Belgian Congo, worked by the Union Miniere du Haut Katanga.

DURING a journey of observation in South and Central Africa last year, I paid a visit to the copper belt in Katanga, Belgian Congo, where great deposits of copper have been developed by the Union Minière du Haut Katanga, a Belgian company, a large number of shares in which are held by the English company, Tanganyika Concessions, Limited. It is not my intention to give a history or general account of this undertaking or to refer to the metallurgical work. I take it for granted that these subjects are sufficiently familiar to readers of the Magazine, who have followed the gradual advance in the copper output with keen interest. My object in this article is to give my impressions of the ore deposits and of their nature and geology.

The copper belt extends for 250 miles east and west and is 30 to 60 miles wide. It is a well watered, thinly wooded country, having an altitude of 4,000 to 5,000 ft. above sea level. Within the limits of the concession, at more than 100 points, there are groups of old native workings, and the presence of copper ore has been ascertained. A considerable number of these orebodies have been prospected by test pits, and a limited amount of drilling has been done on a few. Three mines, the Star of the Congo, Kambove, and Luushia have been opened. Others, the Likasi and Chituru, have been extensively explored by pits and underground work, and large quantities of ore have been proved. At the time of my visit, May 1916, ore was being drawn from the Star of the Congo and Kambove. As regards the actual extent of the deposits, 40,000,000 tons has been mentioned as a possible figure. It will be necessary, however, to do much more testing of the deposits before the correctness of such an estimate can be established. In the meantime it is sufficient to say that sufficiently large amounts of ore have been proved to warrant the provision of a smelting capacity of 40,000 tons of copper per year. At Kambove, Mr. Horner was good enough to give me, in general terms, his estimates of the reserve of high-grade ore. He placed the definitely proved ore at 2,000,000 tons, the "probable" at about as much more, including only the ore



MAP OF CENTRAL AFRICA SHOWING THE POSITION OF KATANGA.

STAR OF THE CONGO MINE SHOWING WORKINGS IN THE QUARTZITE AND SHALES.

above haulage-level, and figuring on a 10% copper content. Similarly an approximation of the ore at the Star of the Congo is 3,500,000 tons of 8% ore proved and probable above haulage, of which 1,300,000 tons may be classed as proved. To this should be added in each case a considerable tonnage for probable and anticipated ore below the present haulage but above water level, but figures are not available. The Star and Kambove are only two of the mines and are not necessarily the largest. In addition to these reserves of high-grade ore there are great quantities of ore of lower content that will be amenable to a leaching process.

THE STAR OF THE CONGO lies at the south-east end of the concession and was opened first because it was most accessible. It lies about ten miles from Elizabethville. The mine is worked by open pit, and is in the midst of an extensive bush-covered plain. In contrast to most of the Katanga ore occurrences, the ore-body does not form a hill rising notably above the surrounding area. The rocks consist of dolomite, shale, sandstone, and quartzite, and Mr. F. E. Studt reports that a mass of thoroughly disintegrated material in the south side of one of the pits represents a decomposed mica syenite. There is little by which to discriminate it in the field from the sandy shale, and the occurrence is notable as being the only igneous rock reported in connection with the copper deposits. The pits worked are two in number, the one on the south being in gently dipping dolomite, and the series constituting really one pit on the north side of the mine, being in steeply dipping sandstone and sandy shale. Between the two is a rib of quartzite containing about 3% of copper, not profitable at present. In this rib is driven a long adit through which the ore is drawn by endless wire rope haulage to the tipple, where it is screened and, in part, washed. Ore from the pits, mined by hand and by steam shovel, is delivered to the adit by cars or trucks pushed by hand.

A cross-section of the orebody is given on the next page. The references to the various beds by lettering in the illustration are as follow :

(*a*) Disintegrated quartzite containing malachite, the so-called "green ore," copper content 17%, width 40 ft.

(*b*) Indurated sandy shale, copper content 8%, width 30 ft.

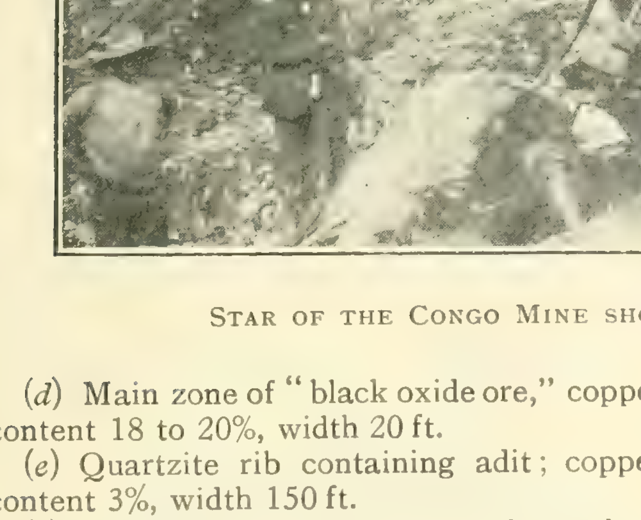
(*c*) Quartzose ore, copper content 5½%, width 30 ft. The boundary between bands (*b*) and (*c*) is not sharp, one at places expanding at the expense of the other.

STAR OF THE CONGO MINE SHOWING WORKINGS IN THE DOLOMITE.

(*d*) Main zone of "black oxide ore," copper content 18 to 20%, width 20 ft.

(*e*) Quartzite rib containing adit; copper content 3%, width 150 ft.

(*f*) Gently dipping dolomite much weathered and showing pinnacles surrounded by residual earth containing black oxide of copper, copper content $7\frac{1}{2}$%, and variable amounts of cobalt; width opened 200 ft.



CROSS-SECTION OF THE STAR OF THE CONGO OREBODY.

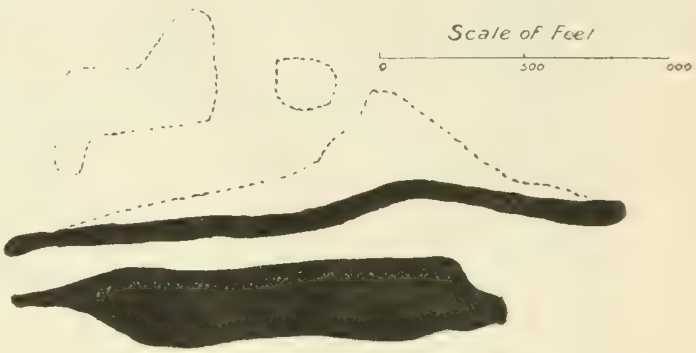
The detailed geology is not clear. There has evidently been considerable movement of the rocks with fracturing and faulting. Whether the latter is profound or represents local slumping cannot be determined off-hand. Later than the disturbance of the rocks there has been a long period of erosion and oxidation. A drilling campaign recently completed has given much information, but this has not yet been published.

THE KAMBOVE mine is situated about 100 miles northwest of Elizabethville, in an area where the topography is considerably rougher than around the Star of the Congo. The mine itself is in a saddle between two hills, but it is on high ground, 150 to 200 ft. above the small stream which flows between it and the main line of railway. The rocks consist of quartzite, sandstone, sandy shales, and phyllites in various shades of red, buff, grey, blue, and green. At the surface they dip about 70°, but this dip moderates rapidly in depth and the appearance is of the exposed and eroded limb of a fold in ordinary sedimentary rocks. While the rocks have been broken and evidently have moved, there is not that sharp diversity of dip and strike that is evident at the Star and at Luushia. Two orebodies, known as the north and south, are now being worked, and a third, or possibly an extension of the northern body, is known at the surface in the hanging wall. The sketches given herewith show in approximate outline the shape of the ground plan of the orebody at the surface and at the adit level.

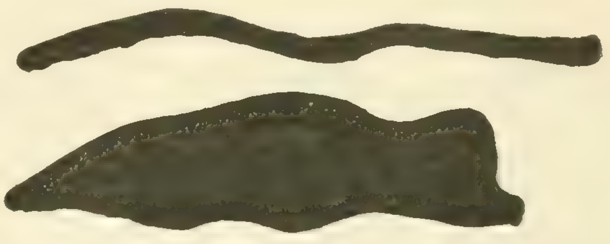
The Kambove mine has been opened by means of a haulage level driven between the two orebodies and 120 ft. below the average height of the orebody. From it cross-cuts have been driven in each direction and rises made to connect with open pits in the orebodies. A steam shovel is engaged in cutting away the barren rib between the north and south orebodies, and as the pits deepen other shovels are to be employed in stripping the north orebody which, because of the dip of the strata, runs in under a hanging of low-grade ore. The individual strata vary in thickness, character, and copper content, but much of their variation is secondary, and essentially there are here two, and perhaps more, bodies of ore in which copper carbonate and oxides impregnate and replace particular beds of sediments. The results of one sampling across the strike of the beds forming the south orebody may be quoted to illustrate the variation in content. This cross-section is marked with figures giving the precentage of copper.

THE LUUSHIA mine is in a flat-lying region covered by red, residual, sandy clay on which grows the usual scrub brush. The ground has been prospected to a depth of about 10 ft. by means of test pits sunk at intervals of 60 ft. in rectangular pattern. All the ground taken from these pits was saved, quartered down, and assayed. On the basis of the information so obtained trenches 10 to 12 ft. deep were cut as nearly as possible across the strike. One of these was widened out to accommodate a railway line into the mine, and in the course of this work about 20,000 tons of self-fluxing ore was taken out, which just about paid for the exploration and the railway connection. In these old pits one sees a mass of red and black pulverulent silicious material containing copper carbonate and oxides, iron, and cobalt. The railway cutting shows much disintegrated sandy shale, silicious dolomite, and red clay. In part the beds have gentle dips, but there is one block of material that shows vertical bedding or foliation, and is so squeezed and contorted as to be almost truly schistose. It lies between rocks that have been little disturbed.

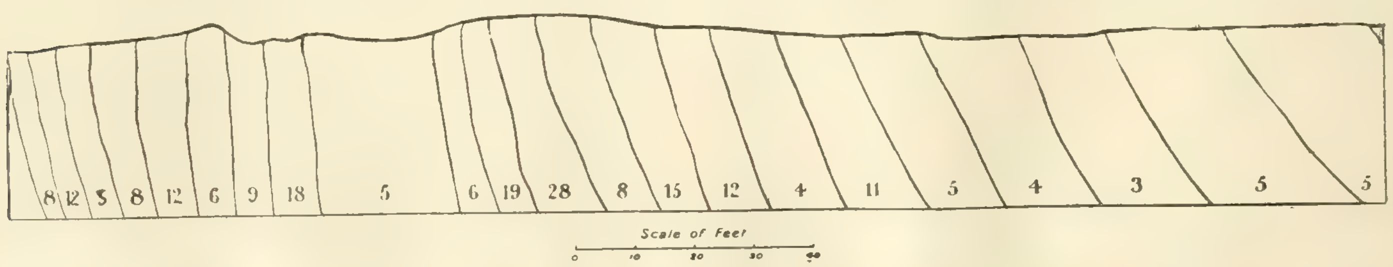
At the north, dolomite comes to the surface with a gentle dip to the south. As shown by prospecting shafts the dolomite continues under the orebody, and at the south end of the explored area is about 200 ft. below the surface. The contact between it and the oxidized ore is reported to be sharp. The dolomite is cracked and broken, and in the crevices, with a calcite gangue, pyrite and chalcopyrite are found. The sulphides also impregnate the dolomite itself, and in one cross-cut a steep dipping bed of black shaly dolomite was found which was 10 ft. thick and had an average content of 10% copper. It was followed for a distance of 200 ft. along the strike, and was locally conformable to the hanging and foot-wall of ordinary silicious dolomite. From the bottom of one shaft, 100 ft. deep and extending into the dolomite below the oxidized ore, a cross-cut was driven 100 ft. in each direction in the dolomite. All the dolomite taken from this shaft and cross-cut was saved, quartered down, and assayed, and found to contain 3% copper in the form of sulphides, mainly chalcopyrite. The sulphur content ranged up to 39%. The oxidized ore at the surface assays 15% copper in large quantities. In one part of the area material assaying 14% copper and 8% cobalt exists in considerable quantity. While sulphides have



GROUND PLAN OF OREBODIES AT THE SURFACE.
Solid colour represents continuous ore. Within the dotted lines are scattered outcrops of orebodies not yet explored in depth. Between the two is a rib of sandstone and shale so low in grade as to be considered barren under conditions at Kambove.



NORTH AND SOUTH OREBODIES AT KAMBOVE ON THE ADIT LEVEL.



CROSS SECTION AT KAMBOVE, ILLUSTRATING VARIATIONS IN THICKNESS OF BEDS AND COPPER CONTENT
(The figures relate to percentage copper content).

Lubumbashi Smelter, where the Katanga Copper Ores are Treated.

been found underlying the oxidized ores at other of the mines, the Luushia is the only one at which enough work has been done to show that there is a considerable body present. Until it is drilled it is unpracticable to give any quantitative estimates.

The Ores now worked consist essentially of quartzite, sandstone, and shale, impregnated with copper, mainly in the form of malachite. This fills fissures and cracks in the rock and is interleaved with the shale bands, so that the edge of the mass looks like the leaves of a book. Small amounts of azurite occur, and there are various alteration products. Black oxide of copper occurs in the thoroughly weathered sandstone and shale ores, and is also characteristic of the "black" or residual ore in the dolomite part of the Star mine. Chalcocite is present but not abundant and, as noted in the description of the Luushia, lean chalcopyrite ores occur in the dolomite, though they are not worked. Cobalt is common, and in certain places quantitatively important. Nickel is found as a trace. Neither gold, silver, arsenic, antimony, lead, or zinc is found with the copper. The ores are characteristically simple in composition, and resemble in this particular the type of ores formed by concentration by meteoric waters in sedimentary rocks, without any necessary direct connection with igneous rocks or igneous agencies. The large orebodies of the Mississippi valley are of this type, though in that region lead and zinc minerals are of first importance, and copper ores, while present and mined in the past, are relatively less abundant. In Katanga and Northern Rhodesia copper mines are more common and more important, though at Broken Hill there are large bodies of lead and zinc with a minor amount of copper. In the Mississippi valley the oxidized ores have already been mainly mined and were always subordinate in importance to the sulphides. In the Katanga region oxidation is more important, and no systematic search for sulphides has ever been conducted. Judging from the little that is known, particularly at Luushia, there are sulphide orebodies in the region qualified to rank with the big disseminated deposits of Missouri and Tennessee.

Lubumbashi Smelter; Near View of New Furnaces.
The stack serves the old furnaces, which are at the back.

THE NISSEN HUT.

Our mining engineers have come out nobly in the war, and many have won distinction for bravery and resourcefulness. Their services have not been confined to fighting. A notable example of work in another connection is provided by the invention of a portable hut by Major P. N. Nissen, D.S.O. His design was submitted in the spring of 1916 to the military authorities, who immediately saw its advantages as a shelter for the soldiers, for its cheapness and efficiency were obvious. Major Nissen is a Canadian, and among mining men his name is already known in connection with stamp-milling. On the outbreak of war he joined the Sherwood Foresters, but was soon transferred to the Royal Engineers.

As will be seen from the photographs which we reproduce herewith, the hut is semi-circular in cross-section. The Tommies liken it variously to half a London underground tube, to a lap-dog with big eyes, no nose to speak of, short legs, and a saucy little tail sticking up at the back, and, when viewed in bulk at a distance, to an army of slugs. The problem before the military authorities was to devise a cheap shelter where the men could be warm and dry, cheap enough to supply by the fifty-thousand, portable and easily erected. The Nissen hut won the competition. It has no vertical walls, but consists virtually of a curved corrugated iron roof. Inside is another cylindrical wall of match-boarding, a few inches apart from the iron. The intervening air space acts as a non-conductor of heat, thus keeping the interior warm in winter and cool in summer. The hut stands on three longitudinal sills 27 ft. long. On these rest 12 panels of floor-boarding. The roof is in interchangeable pieces of curved corrugated iron, each 9 ft. long, overlapping by two corrugations. The lining of ½ in. match-board is fastened to ribs of angle iron that follow the semi-circle of the roof. There are five of these ribs, each of which is in three segments. The various parts are fastened together with bolts. When the match-boarding contracts with heat, the cracks are closed by knocking each board toward the floor. Thus a ventilating space is left at the top of the arch between the wood and the iron. At one end is the door and windows, in the latter a non-inflammable horny substitute for glass being used. At the other end is a stove of Canadian type which will burn green wood. The bedding is arranged so that the men have their heads toward the longitudinal walls. At other times the beds are rolled up and packed on the floor by these walls, and the centre space, where the men can stand erect, is filled with tables. Twenty-four men can sleep in the hut, and 52 can be accommodated at mess. It is found by experience that six men can erect the hut in six hours. The hut will clearly have many applications apart from warfare. Mining engineers will appreciate a cheap portable shelter, made in interchangeable sections, none of them too heavy for lifting, and erectable without skilled labour, and with no other tool than a spanner.

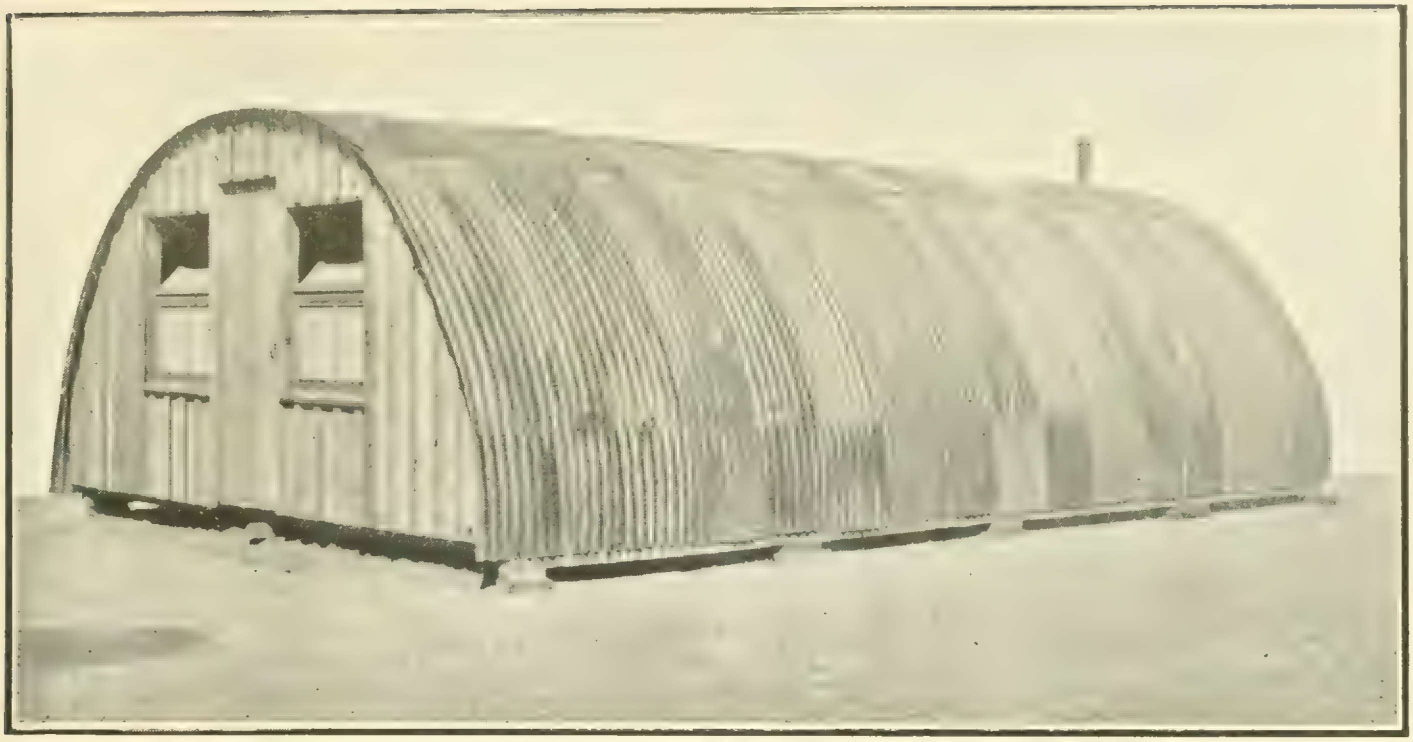
Output of Minerals during 1915.

The official returns for the output of minerals and metals in the United Kingdom during 1915 have only just been published.

	1914 Tons	1915 Tons
Alum Shale	6,078	7,911
Antimony Ore	—	2½
Arsenical Pyrites ...	—	421
Arsenic	1,988	2,496
Barium (Compounds) ...	48,930	62,477
Bauxite	8,286	11,723
Bog Ore	2,342	1,986
Chalk	4,291,170	3,233,897
Chert, Flint, &c. ...	76,213	102,698
Chromite	100	—
Clay and Shale	13,124,361	8,871,821
Coal	265,664,393	253,206,081
Copper Ore	2,373	579
Copper Precipitate ...	185	243
Fluor Spar	33,816	33,123
Gold Ore	47	5,086
Gravel and Sand ...	2,498,872	2,350,267
Gypsum	265,365	247,229
Igneous Rocks	7,135,243	6,085,415
Iron Ore	14,867,582	14,235,012
Iron Pyrites	11,654	10,535
Lead Ore	26,013	20,744
Lignite	300	1,783
Limestone (other than Chalk)	12,158,441	11,115,909
Manganese Ore	3,437	4,640
Natural Gas	87,000 cu. ft.	87,000 cu. ft.
Ochre, Umber, &c. ...	11,069	8,989
Oil Shale	3,268,666	2,998,652
Salt	2,069,989	2,005,605
Sandstone	3,464,528	2,520,856
Slate	318,912	226,037
Soapstone	180	850
Sulphate of Strontia ...	13,157	640
Tin Ore (*Dressed*) ...	8,085	8,144
Tungsten Ores	205	331
Uranium Ore	344	82
Zinc Ore	15,419	12,057

METALS OBTAINABLE BY SMELTING.

Copper	341 Tons	234½ Tons
Gold (Bar)	99 Oz.	1,256 Oz.
Iron	4,786,090 Tons	4,567,351 Tons
Lead	19,378 „	15,520 „
Silver	146,444 Oz.	96,448 Oz.
Tin	5,056 Tons	4,968 Tons
Zinc	5,208 „	4,096 „



EXTERIOR OF THE NISSEN HUT.

INTERIOR VIEW OF THE NISSEN HUT.

DISCUSSION

Fluorite-Galena Deposits.

The Editor:

Sir—Professor Louis' welcome article on the lead-fluorite deposits of Weardale is of timely interest, especially to those of us who consider that full justice has not been done yet to the base-metal resources of the homeland. It is generally admitted by economic geologists that the systematic investigation of ore deposits from the genetic standpoint is the best principled and most scientific method of studying the various problems of ore occurrence, and is one that has shown itself to be of no small value in the practical guidance of exploratory and mining operations. It is to be regretted that Professor Louis' article sheds no light on the genetic aspect of the Weardale occurrences, nor does he throw out any general suggestions as to their probable mode of origin as disclosed by the progress of mining operations or such as might be disclosed by thorough and careful study of the geological evidence. It is unfortunately true that very little serious geological work on modern lines appears to have been done on any of the numerous lead and zinc deposits in this country, nor is the position much better in regard to the deposits of tin and copper. There are good grounds for believing that the natural resources of the British Isles in the form of base-metal ore deposits are by no means exhausted, and that they deserve more attention than they have received of late years. It is the more desirable therefore that efforts should be made to put our knowledge of the ore deposits of the homeland on a more satisfactory scientific footing than is the case at present.

Perhaps one of the most interesting features of the Weardale deposits, and the same remark applies to many other lead-ore deposits in this country, is the association of galena with fluorite and siderite. It is often contended that the presence of fluorite implies the intervention of magmatic agencies in the deposition of the ores. So strongly rooted is this view that the presence of fluorine compounds is almost always regarded as a criterion of magmatic activity in the formation of the deposits.

It is a matter of interest to find therefore that by far the largest accumulations of fluorite, not only in this country but at foreign localities, occur in close conjunction with lead (galena), which is usually a metal that is confined to comparatively shallow horizons and appears to have been deposited as a rule from fairly cool solutions. From its common occurrence in so-called pneumatolytic deposits however, fluorite is often regarded as at least a moderately "high temperature" mineral, and as essentially a mineral of magmatic origin. It is open to serious doubt whether fluorite is in all cases of magmatic origin. It is significant that these large deposits of fluorite occur either in or in close conjunction with limestone under conditions which otherwise suggest deposition from cool solutions, while any relationship that may subsist with igneous rocks is usually so obscure that it cannot be said to be satisfactorily established.

The fact that the waters of the ocean contain appreciable quantities of fluorine, coupled with the occurrence of fluorine as a general constituent of the adjacent limestone formations, in those cases where the matter has been carefully investigated, together with experimental evidence on the solvent powers of alkaline bicarbonates on various fluorine compounds, appear to be strong evidence for the view that low temperature alkaline saline circulating waters of the kind often found in the districts where such deposits occur, may give rise to fluorite deposits without any intervention of magmatic agencies. The problem is one that deserves closer attention, not only on account of the light that may be thrown on the more precise conditions of occurrence of the galena-fluorite deposits, a matter of possible economic value, but also on the question of fluoritization generally. I have indicated elsewhere that there are grounds for suspecting that some at any rate of the lead-zinc deposits in this country may have been deposited from artesian circulating waters, after the manner of the famous Joplin deposits. It seems possible that even the galena-fluorite deposits may have been deposited from solutions circulating essentially in sedimentary rocks only. The presence of siderite as an accompanying mineral may certainly be regarded as collateral evidence in support of a purely sedimentary origin for the cavity fillings or replacements though, of course, it is not conclusive. The whole subject of the study of the ore deposits of the home country on modern lines from the genetic standpoint is one that might well be taken in hand by the Geological Survey. I venture to suggest that if similar care and acumen were brought to bear on the study of the ore deposits of the homeland as has been done in the case of our coal resources, the foundation would be laid for a revival of a profitable base-metal mining industry in these islands.

W. H. GOODCHILD.

London, February 7.

Mining Magazine Indexes.

The Editor:

Sir—It has often struck me that there should be an Index published of everything that has appeared in The Mining Magazine up to date. The Magazine is the only paper which I endeavour to keep now-a-days in bound form, and it is a most valuable record. But I have the greatest difficulty in referring to it, as I do not know in what year articles were published on specified subjects.

C. W. PURINGTON.

London, February 22.

[We refer to this subject in our editorial columns.—EDITOR.]

PERSONAL

W. T. ANDERSON is relinquishing the management of the East Rand Proprietary Mines and coming to England on war work.

W. N. BENSON has been appointed professor of geology in the Otago University, New Zealand.

R. B. CAPLES, of Anaconda, is going to Tasmania to conduct experiments on electrolytic treatment of the zinc ores of the Mount Read mines.

ARTHUR A. COLE has been re-elected president of the Canadian Mining Institute.

A. R. DEWAR is here from Nigeria.

HARRY D. GRIFFITHS is on his way back from Burma.

SIR ROBERT HADFIELD has been elected president of the Society of British Gas Industries.

ROBERT HAWXHURST is manager for the Eden Mining Co. in Nicaragua.

CHARLES JANIN is in Russia.

H. EWER JONES has left for France to take up ambulance work for the British Red Cross.

JOHN JOYCE has been appointed manager of the New Boddington mine, Goongarrie, West Australia.

J. T. KEATING is leaving for Prestea Block A, West Africa.

A. S. LILBURNE has been appointed manager of the Occidental gold mine, Cobar, New South Wales.

R. N. LYMAN, lately manager of the Seneca-Superior mine at Cobalt, has been appointed chairman of the Elliott Kirkland Gold Mines, Limited.

P. H. M. MACINTOSH, lately with the Mt. Bischoff Tin Co., Tasmania, is lieutenant in the Australian forces in New Guinea.

T. H. MARTYN has returned to Sydney after a visit to Russian alluvial gold deposits, made on behalf of the Malaya Tin Corporation.

PERCY R. MIDDLETON is manager of the Abercrombie Copper Co., a company formed to acquire the property of the Lloyd company at Burraga, New South Wales.

LIEUTENANT J. V. MOORE is with the 257th Company of the Royal Engineers in France.

WILLIAM MOTHERWELL has opened an office as consulting engineer at Nelson, British Columbia.

MAJOR P. N. NISSEN, of the Royal Engineers, has been awarded the D.S.O.

E. F. PETERSSON has gone to Spain.

C. H. POWELL is reopening the Mount Biggenden bismuth mine, Queensland.

DAVID RICHARDS has been appointed chairman of the Plymouth Consolidated Gold Mines Ld.

L. D. RICKETTS has gone to South America on business for the Andes Copper Company.

A portrait of ROLLIN D. SALISBURY, professor of geology in the University of Chicago, has been presented to the university by his former students.

A. J. M. SHARPE has arrived in London from Australia to undertake the duties of London secretary of the Zinc Producers' Association.

S. S. SORENSEN is returning to the Braden copper mine, Chile, after a vacation in the United States.

T. M. STANTON, lately with the Cananea Copper Co., Mexico, has been appointed manager of the Llallagua tin mines, Bolivia.

M. H. SULLIVAN, lately at the Trail smelter, British Columbia, has been appointed superintendent of the smelting and refining works of the Bunker Hill and Sullivan Company.

E. COPPEE THURSTON is with the smelting department of the Bunker Hill & Sullivan Co. at San Francisco.

J. T. WARNE is coming home on leave from the Ashanti gold mines, West Africa.

R. C. WARRINER, manager of the Crown Mines, has been appointed consulting engineer for the East Rand Proprietary Mines.

D'ARCY WEATHERBE left for New York on February 28.

SAMUEL WEIS, dredging engineer for the Lena Goldfields, is in the United States on business connected with the new dredge.

ERNEST WILLIAMS is with the Munitions Department at Woolwich.

JOHN WILSON has resigned the chairmanship of the Arizona Copper Co., Ltd., owing to advancing years. He was originally elected to the board in 1883.

Among the recipients of Knighthoods in the distribution of honours last month were H. ROSS SKINNER, the Rand mining engineer; DRUMMOND CHAPLIN, lately a director of the Consolidated Gold Fields and now Administrator of Rhodesia, and MAJOR J. NORTON GRIFFITHS.

We regret to record the death of JAMES EDWARDS, who was for twenty years the secretary of the Great Boulder Proprietary Company, of Kalgoorlie.

LIEUTENANT L. H. H. HUDDART has succumbed to malarial fever in German East Africa. He was well known in Nigeria, where he was at one time an Inspector of Mines. He was a member of the Committee dealing with the revision of the mining law of that Colony. Joining the army on the outbreak of war, he went through the campaign in the Cameroons. Afterwards he exchanged into the Royal Engineers. He went with General Cunliffe's force to East Africa on the conclusion of fighting in the Cameroons.

AUGUST RAHT, who died at San Francisco recently, was one of the famous German-American metallurgists who founded lead-smelting on modern lines in the United States.

SPECIAL CORRESPONDENCE

CAMBORNE.

St. Ives Consolidated.—This group of mines has now been acquired by the Thermo-Electric Ore Reduction Corporation, Ltd., of which Mr. A. F. Maclaren is the managing director. This company is engaged in producing ferro-tungsten at works erected at Luton, and owns extensive wolfram properties at Wolfram Camp, Queensland. It is proposed to transfer the plant on the Consols section of the St. Ives group to the mines in Queensland, and Mr. F. C. Cann will shortly be temporarily leaving Cornwall to report on the Queensland properties and to supervise the erection of this plant. This was the immediate purpose of the purchase of the St. Ives group, but Mr. Maclaren, who has an intimate knowledge of and faith in the possibilities of these mines, does not intend to stop operations. The absence of the requisite labour must of necessity curtail development, and it is proposed to concentrate what is available on the Giew section, leaving the Consols and Trenwith sections alone until the existing conditions change. At Giew, Frank's shaft is being sunk on the lode to the 202 fm. level, the bottom being at present about 184 fm. When it reaches the depth named, levels will be driven east and west on the lode, and a connection made with Robinson's shaft, which was put down to that level by former workers. Robinson's shaft is, however, badly crushed in places, so another vertical shaft is being started from the 60 fm. level, rising and sinking at the same time. This is the immediate development programme, and when completed, a large reserve of ore should be available. Good values are being met with at present in Frank's shaft, the lode producing 80 lb. per ton (vanning assay) over a width of 5 ft. The average of recent developments in general has been 29 lb. over a width of 3 to 4 ft. The mill will be run only on ore taken out in the course of development.

Dolcoath.—Judged solely by the financial result, the past six months working of Dolcoath has been disappointing, but looked at from a mining standpoint, one can extract some encouragement from the report which has been recently issued. The manager has been beset with difficulties caused by lack of adequate labour, higher prices for materials, a falling off in stoping values, and a lower price for tin. Given the pre-war (that is, the average of the 3 years 1911-13) price for tin, even under the existing abnormal conditions, a decent profit would have been earned, and this only emphasizes the reasonableness of the claim, referred to by me in the last issue, that the Excess Profits Duty percentage standard should be substantially increased for Cornish tin mines generally, or better still, that, under the special circumstances, they should be totally exempt from such duty. The output was 37,963 tons, the lowest for close on twenty years, and this shows a fall of 3,421 tons on the previous six months' figure. The production was 500 tons of black tin, a decrease of 76 tons, and the average recovery was 29·53 lb. per ton against 31·2 lb. for the last half-year. With pre-war working costs and output, a recovery of 29 lb. would pay well at Dolcoath, even with black tin fetching less than £100 per ton; but it is doubtful if ever an all-in cost of 25s. to 26s. per ton will be seen again at Dolcoath, and it is obvious that the management must concentrate on development with a view to locating new orebodies containing a higher mineral content. To this end, a diamond-drill is to be employed, and this should speedily indicate what the future has in store for Dolcoath. In these days of limited labour, the use of a diamond - drill is of great value, as the data disclosed enables the management to concentrate development work on those points which are likely to open up profitable ground quickly. The working cost (excluding royalties and depreciation) was 26s. 4d. per ton, and in this connection one cannot refrain from remarking that when the company is operating the mine at a loss, a royalty on the mineral recovered of 15% on the working cost is outrageously high. No profit, no dues, would be a more equitable arrangement, and encourage the shareholders to develop the property. The loss for the half-year was £2,910 (excluding depreciation £1,258) while £4,110 of the cost of development was charged to capital account. The principal developments have been: (1) on the main lode at the 440 fm. level east of New East shaft, where it seems likely that a block of payable tin ground will be opened up; (2) on the main lode at the 510 fm. level east of New East shaft, where the operations carried out have thrown encouraging light on the bottom workings, and in the words of Captain Arthur Thomas are "significant of possibilities"; (3) the 440 and 490 fm. levels west of Harriet shaft on the south part of the main lode about which the manager spoke so hopefully at the last meeting, but which, to his great chagrin, have turned out disappointingly so far, although there is a chance yet of cutting something good between the present end and the Stray Park cross-course; and (4) the 238 and 314 fm. cross-cuts to intersect the Harriet series of lodes, in the former of which a 3 ft. lode has been met with assaying 40 lb. per ton for that width.

TINCROFT MINES.—Contrary to general expectation, the accounts for the half-year ended December 31 last show a loss of £1,191, and this is attributed by the management to increased development. It is doubtless true that but for the increased development, a small profit would have been earned, but as the extra footage was 663 at an approximate cost of £3 per foot, it is obvious that this was not the main cause of the difference between a profit of £3,691 last half-year and the loss made in the half-year under review. The chief troubles have obviously been a fall in the grade of ore treated (the recovery of tin from which has fallen from 21·22 lb. to 18·69 lb. per ton) and the decrease in the realization price of the black tin sold. The tonnage handled was 29,095, and the weight of black tin marketed was 246 tons, which realized an average price of £95 per ton. The arsenic and wolfram recovered realized respectively £8,508 and £3,905, the former showing an increase of £2,000, although whether this was due to higher prices or increased production is not stated. The working cost (including royalties) was 26s. 7d. per ton, or 11d. per ton higher than the previous half-year. The development footage equalled one foot for every 15 tons milled, and this ratio is by no means too high for a mine in the position of Tincroft. From the statement made by Captain W. Thomas at the meeting of shareholders, it is clear that the developments carried out on the South lode have laid open stoping ground of payable grade at existing prices, and it is satisfactory that the best values have been met with in the 208 fm. level, which is the deepest point at which this lode has been attacked. Good arsenic and wolfram values are being met with in the upper levels, which have been re-opened more particularly because of the demand for those minerals at the present time. A new magnetic separator has been installed, and the old one is now being overhauled. Altogether, the outlook seems promising, and certainly the manager is to be congratulated on the miner-like way in which he has handled matters since his appointment.

EAST POOL & AGAR.—At last an orebody of some magnitude and high mineral content has been developed in Cornwall over which one can reasonably enthuse, and the first fruits of this discovery are seen in the increased tin recovery, which has risen from 16·42 lb. in 1915 to 25·16 lb. per ton in 1916, although less than 20% of the output came from this source, and this presumably mainly from the developments on the new lode. The ore treated was 81,395 tons, practically the same quantity as last year, but the combined recovery is less per ton as the following figures show:

	Tons recovered		Price realized		Yield per ton lb.	
	1915	1916	1915	1916	1915	1916
			£	£		
Black Tin......	597	914	89	103	16·4	25·1
Wolfram	127	100	157	174	3·5	2·8
Arsenic.........	805	527	14	24	23·3	14·5
Copper	15	11	8	16	0·4	0·3
	1,544	1,552			43·6	42·7

While the output of tin has substantially increased, the production of wolfram and arsenic has fallen. The fall in the wolfram production is to be regretted, seeing the need for this mineral at the present time. The working cost has risen from 21s. to 25s. 3d. per ton, partly because of increased development, but mainly through higher wages and the increased cost of materials. From the detailed report of the development on the Rogers lode, it is obvious that substantial reserves of high-grade tin and wolfram ore have been opened, and that a successful future is assured for many years to come at anything like present metal prices. The management are to be congratulated on the excellence of the work done during the past year, and for the able way in which the results are presented to the shareholders.

STATE SUBSIDIES FOR DEVELOPMENTS OF ORE DEPOSITS.—After a good deal of hesitation, but finally converted by the necessity for an increased home production of wolfram, the Government has decided to make available funds for the development of promising wolfram deposits in the West of England. The first to benefit by this decision is the company owning the Park-an-chy mine situated at Scorrier, which readers of this Magazine will recall was previously worked on a small scale by Messrs. Edgar Allen & Co., the steel-makers of Sheffield. The shaft on this property has been sunk to a depth of 60 to 70 fathoms, but no stoping has been done below the 30 fm. level. The main lode bears chiefly wolfram, and with depth the values increase, the average wolfram content below the 20 fm. level being about 28 lb. per ton. In this case, it appears that £10,000 is to be advanced on loan for developing the mine and providing the necessary plant. There are many other promising wolfram properties in the St. Day and Altarnum districts which deserve attention, and which doubtless would have attracted capital ere this but for Treasury restraints, and one can only hope that the owners will now be given a chance to prove their possibilities. The extension of State help to home tin mines would be a wise step at such a time, for increasing freight difficulties are bound, sooner or later, to affect overseas supplies. The possibilities of Cornwall as a tin producer are great, and there are several mines already in operation where, given adequate labour and capital, the returns could speedily be substantially increased. This is a matter which the Cornish Chamber of Mines might usefully press on the Government, which now, for the first time, seems to be beginning to realize the value of the mineral wealth lying undeveloped at its very doors. It is noteworthy that the newly appointed Director of National Service has classed tin and wolfram mining among the industries which are regarded as of importance from a national point of view, and this only goes to justify the criticisms in these columns long ago directed against the recruiting tribunals (before the establishment of the mining court) when the mines were being denuded of miners for service with the Army at grave risk to the industry. These miners are now badly needed.

EAST CORNWALL.—The Duchy of Cornwall is also undertaking the development of certain of its wolfram properties in the neighbourhood of Tavistock. On the westerly part of Hingston Down, prospecting work is being conducted at Kit Hill by trenching across the surface of the hill. So far a number of promising tin and wolfram lodes have been intersected, one being 21 ft. wide. Many years ago, a level was driven into the hill for 2,000 ft., and it is now proposed to continue this to connect with an old shaft. This will enable the ore to be cheaply mined. Work is also being conducted at Hengiston Down, where a quantity of wolfram ore has been laid open. It is proposed shortly to re-open the Clitters mine. At present, work here is confined to re-modelling the milling and dressing plant, where, it will be recalled, the first Wetherill magnetic separator in the West of England was installed. It is a noteworthy departure on the part of the Duchy of Cornwall to actually conduct mining operations, and it is to be hoped that the experience gained will lead the Duchy to support by example reform in the matter of royalties and leases, and also to use its powerful influence to direct attention to the possibilities of the West of England as a mining region.

IRON DEPOSITS OF THE WEST OF ENGLAND.—When the Premier recently laid stress on the importance of increasing the home production of iron ores, the possibilities of the West of England in this direction occurred to many people. At the recent Tincroft meeting, Mr. John Gilbert (the representative of Viscount Clifden) stated that representations had at once been made by him to the Government, and his lordship had offered to lease the iron mines on his property to the Government on their own terms. The opening of the rich hematite deposits in Spain had the effect of substantially reducing the prices obtainable for iron ores, with the result that since 1880, very little mining for iron ore has been carried on in the West of England. The Great Perran iron lode, at the north end of Perran Bay, can be traced for several miles, and its characteristics have at various times been fully described by our leading geologists. In some places, it has been extensively mined above adit, notably at Gravel Hill and Penhale, and at others, the lode has been quarried, as at Mount, Treamble, and Great Retallack. At Duchy Peru, the lode was worked to about a depth of 40 fathoms. The lode varies in width from a few feet up to fifty feet, the capping being of brown hematite overlying spathic carbonate of iron. The ore was richest at the deepest points reached, but the late Mr. J. H. Collins held the opinion that in depth the mineral content of the lode would change to copper.

Then in the St. Austell district, there is the Ruby iron lode, which was worked with success at Wheal Ruby for a depth of 40 fathoms from surface, and also at several other places. The Treffry iron mines in the Luxulyan valley are reported to have produced excellent red hematite in fair quantity, although the lode was worked only to a very shallow depth.

Close to Lostwithiel station are situated the Restormel iron mines which were working in 1835, and were visited by the late Queen Victoria in 1846 under the guidance of the late Mr. Richard Taylor. The production prior to the time of its closing down in the early eighties was known to be very substantial. These mines were re-opened in 1908, but little was done. The shaft was then 62 fm. deep from surface, and an analysis of the ore gave: Iron 55·7%, silica 7·5%, phosphorus 0·105%. The ore was shipped from Fowey to the north of England.

In Devon, at North Molton, there are several lodes which were successfully worked for spathic iron ore when it was worth 20s. per ton or more, and in this district the Brendon Hill mines were operated for many years by the Ebbw Vale Iron Co. of South Wales.

Given adequate labour and the necessary capital, together with a reasonable selling price for the ore, there is no reason why the mining of iron ore should not be carried on once more in the West of England on a large scale.

WESTERN AUSTRALIA.

WESTONIA.—The shaft on the Edna May mine has reached a depth of 426 ft. in greenstone, and the cross-cut at the 385 ft. level has been driven to 190 ft. An advance bore-hole 10 ft. in length shows that the cross-cut is just on the foot-wall of the lode, and borings assay 40s. per ton. The installation of the additional air compressor now ensures sufficient air both for the mining and treatment plants. [Progress at the Edna May group will be more easily followed by reference to the article and plan of workings published in our February issue.—EDITOR.]

The Edna May Central is sinking the main underlie shaft to the 300 ft. level, and when this is completed the company will probably endeavour to pick up the continuation at depth of the Consolidated new lode, which is a short distance from the Central boundary. The main shaft on the Edna May Consolidated has been repaired and overhauled, to enable operations being started for the development of the lode referred to above. The lode, as far as it has been opened, has a width of 17 ft. and the company has felt justified in purchasing a large winding plant.

The Edna May Deeps is also sinking its main shaft, which is in gold-bearing quartz, but the main lode has probably been affected by a hornblende dyke at this point. The cementation process for coping with the water difficulty, described in a previous article, is still being used with satisfactory results; it has been patented and will probably be used on other mines, whenever a heavy inflow of water is anticipated.

About three miles to the west of Westonia, a lode has been cut at a depth of 130 ft. in the Pertha M. lease, from which a crushing was taken recently from a width of 14 ft., and yielded over 1 oz. to the ton. A development option has been taken on the lease by the Edna May Junction Company.

LEONORA.—There has been a rivival in mining in this district. The Leonora Gold Blocks, which was acquired last year by a Melbourne company, is developing satisfactorily. This mine has been worked privately for some years, and paid its owner good dividends, though with an obsolete plant. The company has wisely pushed on with shaft sinking and driving. At the 400 ft. level the drift is in the lode for 96 ft. in ore worth 70s. per ton over a width of 36 inches. A new plant of 10 stamps, three grinding-pans, and a decantation slime process is to be installed shortly, and under the present sound policy the mine should give a good account of itself.

The Auckland and Fortuna mines have been transferred to the New Chaffers Company. The former, which has hitherto been worked by prospectors and has a big, but very hard ore deposit, will be equipped with a rock-drilling and winding plant, preparatory to the installation of a mill.

The Gwalia Central Company, having practically depleted its ore reserves above water level on its Trump lease, has installed a pumping plant, so that the rich shoots of ore may be worked below that zone.

LAVERTON.—The output of the Lancefield mine for December was 6,430 tons, valued at £9,347. It is pleasing to record this result from a mine that was shut-down, and then started again by a few West Australian mining men. These men had sufficient faith to put up fresh capital, and, with their united technical experience, they have made a success of it.

MINING CONFERENCE.—The present Minister for Mines proposed to call a conference of men representing the various branches in mining, metallurgy, and prospecting, to see what steps could be taken to improve the industry. The question of prospecting on sound lines is one that could be discussed with profit. Although the collaboration of the prospectors and the members of the Geological Survey has so far not produced any practical results, the idea is right. This will probably be one of the principal themes of discussion. More mines are needed to replace those which are being worked out. These are to be found, but, unfortunately too few prospectors are looking out for them.

KALGOORLIE.—The points of interest on the mines at Boulder are mainly economic. There are no new treatment plants being erected, and unfortunately no developments other than on known bodies of ore. But the constantly increasing price of stores and shortage of efficient labour are more difficult to grapple with than the problems of extraction and ore treatment which the managers and metallurgists were called upon to overcome prior to the war.

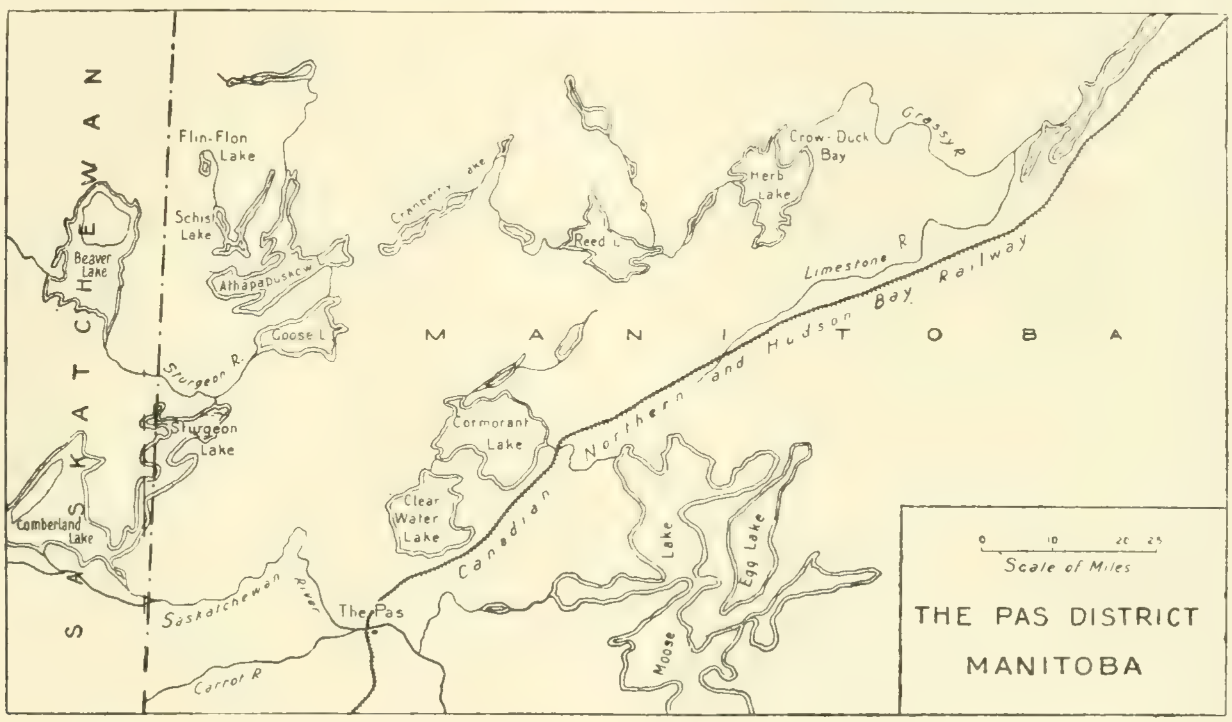
LABOUR. — For some time discussions have been held among the members of the Miners' Union, with reference to affiliation with the Australian Workers' Union. A ballot has now been held and the Federated Mine Employees' Association has decided to amalgamate with the A.W.U. The question arises, will this branch uphold its decision in electing an ardent conscriptionist as president, by backing him up in this ? He will meet with the most strenuous opposition by the members of the A.W.U. in the Eastern States, who expelled Hughes and those of his fellow unionists in Parliament from the Union, because they advocated conscription. This question of the control of the whole of the labour unions in Australia by the Australian Workers' Union will have a far-reaching effect, which the public do not seem to realize. One body of men will be able to call out on strike the whole of the members of the Union throughout the Commonwealth. Such a position is giving employers and representatives of capital food for serious thought.

TORONTO.

PORCUPINE.—The four-weekly statement of Hollinger Consolidated for the period ended December 31 shows gross profits of $225,057 from the treatment of 49,106 tons of ore, of the average value of $8·49 per ton, at a working cost of $3·76 per ton. This is a slight fall as compared with the previous three months, due to labour shortage. The operating profits for the year were $2,866,984, with current and gold assets at the close of the year amounting to $981,263 and current liabilities of $425,211. The deficit existing since the merger has been reduced to $79,015, the sum of $180,000 having been received as premiums on the new stock issue. Construction work on the new 100-stamp mill is complete, and the machinery is being installed in units of 20 stamps each, the first of which is now ready for operation. Preparations are going forward underground for handling the increased tonnage that will be required on account of the doubling of the mill capacity. During January the Dome Mines produced bullion to the value of $181,000, from 89,600 tons of ore of the value of $4·57 per ton, at a working cost of $2·81 per ton. The latter item, though showing a slight advance, is regarded as very moderate considering the increase in the cost of mining materials. The McIntyre during January produced bullion of the value of $145,297 from the treatment of 14,317 tons of ore, of the average value of $10·60 per ton. The new 600-ton mill is in operation, though not up to full capacity, and the daily production is between five and six thousand dollars. The Newray, having raised further funds for development by a new stock issue, has let a contract for 10,000 ft. of diamond-drilling on the western half of the property, hitherto unexplored. The position of the Schumacher has been much improved by development on the 200 ft. level of No. 4 shaft, where a large vein has been proved to be 22 ft. in width of ore averaging $6 to the ton. A cross-cut being driven from the same level is expected to cut another large vein. The Keora has cut two veins, one of them 2 ft. and the other 5 ft. wide, by diamond-drilling at the depth of about 300 ft. The gold content is stated to be about $12 to the ton. The McRae Porcupine, which has an area of 92 acres with good surface showings, is offering 200,000 treasury shares at 50c. per share to raise funds for development. A large orebody has been proved at the Davidson, where a cross-cut on the vein at the 100 ft. level has been driven for 150 ft. in ore averaging between $5 and $6 to the ton. The same vein is being cross-cut at the 300 ft. level.

KIRKLAND LAKE.—At the Kirkland Lake mine, which is being worked under option by the Beaver Consolidated, the shaft is down to the 500 ft. level, where a cross-cut will be driven to cut the large orebody found on the upper levels. On the 300 ft. level this orebody is 42 ft. wide and is stated to average $9 in gold per ton. It is reported to be still richer at the depth of 400 ft. The Beaver will exercise its option. The Lake Shore has placed an order for a 100 ton ball-mill, which it is expected will be installed in March. The mill of the Tough-Oakes is in operation, and the cost of working has lately been reduced. The Dominion Reduction Co. is planning to enter the Kirkland Lake field.

THE FLIN FLON LAKE MINING DISTRICT.—Great progress was made during 1916 in the development of the Flin Flon copper-mining district, situated on the boundary between Manitoba and Saskatchewan, 90 miles to the northwest of The Pas, Manitoba. The first discovery was made in August 1915, and though so short a time has elapsed, ore to the estimated value of $45,000,000 has been proved. There are two large properties. The Great Sulphide Co. owns 10 claims on the shore of Flin Flon Lake where a large outcrop of oxidized sulphides is exposed. The length of the deposit is estimated at 2,000 ft., and at the widest part it is 300 ft. in width. It has been trenched for 1,700 ft. and sampling gives a value of $10 per ton in copper, silver, and gold, the copper content averaging $1\frac{1}{4}\%$. Diamond-drilling has proved 3,000,000 tons of ore. The other property is that of the Mandy Mining Co., a subsidiary of the Tonopah Mining Co. of Nevada. It is located on Schist Lake about three miles southeast of Flin Flon Lake. Active development was begun last March. Diamond-drilling disclosed 110,000 tons of ore averaging 22% copper with some gold and silver contents. Forty men are now at work getting out ore, which is being hauled to Sturgeon Lake 40 miles distant, from whence it will be taken by barge when navigation opens to The Pas and shipped by rail to British Columbia for treatment. A complete plant will be installed as soon as possible.



COBALT.—The increase in the price of silver has greatly stimulated operations in the Cobalt area, and has given to many properties a new lease of life. Work has latterly been much interfered with by unusually severe winter weather. The efforts of the Beaver Consolidated management to discover paying silver deposits at depth on the lower contact between the diabase and Keewatin formations have at length been successful. A rich high-grade vein 4 to 6 in. in width has been encountered on the 1,600 ft. level. It is reported to carry 2,000 oz. ore. This was followed by the finding of another vein paralleling the first, with 7 ft. of wall-rock between the two heavily shot with leaf silver. This discovery is considered of great importance to that section of the district, the life of which will probably be considerably prolonged if deep mining can be profitably undertaken. The Timiskaming shaft has now only 40 ft. to go down in order to reach the lower contact, where it is proposed to connect the workings with those of the Beaver to secure better ventilation. The Timiskaming will then sink 200 ft. further, and open a level at 1,800 ft. Its production for 1916 was 1,263,848 oz. and the net profits $352,890. At the Hargraves a 6 in. vein has been struck on the 75 ft. level, and high-grade ore is being bagged. The discovery is the most important so far made on this property. Good ore has also been found on the 375 ft. level. The 150 ton oil-flotation plant of the Coniagas has been completed and is in satisfactory operation. A 2 in. vein has been struck on the 150 ft. level. It is of low grade, but the wall-rock carries much good milling ore. The Apex has encountered a 54 ft. vein at 900 ft. in a diamond-drill hole. The Gifford has increased its capital from $250,000 to $1,000,000. The annual report of the Crown Reserve indicates that the mine is approaching exhaustion. Gross profits were $191,823 and operating costs $188,849, leaving a small net profit of $2,973. The revenue from investments, the principal of which is Porcupine Crown stock, was $145,413. A 4 in. vein was recently struck at the 700 ft. level.

JOHANNESBURG.

THE FAR EAST RAND.—Attention has been attracted by Mr. Ernest Williams' letter on the advisability of the State doing something direct toward the development of the Far East Rand. In previous letters I have drawn attention to the same subject, and suggested that neighbouring properties might be used as a jumping-off place for that purpose. Mr. Williams goes much further, and suggests that the State should sink twin or triplicate shafts to be used for exploitation purposes by several companies or individuals. This suggestion has the merit of overcoming the great drawback of depth on the Far East Rand, and rendering the ground available to smaller companies; but it must be said that providing the ground has a reasonable prospect of being profitable, the mining groups on the Rand, on equitable conditions, will always be able to come forward with sufficient capital for exploitation purposes.

It seems more reasonable to suggest that the State, occupying as it does the position of lessor, might be expected to sink prospecting shafts in doubtful areas, and drive upon the reef if necessary, prior to calling for tenders to work such areas. Those intending to submit offers would then have something definite on which to base their tenders, and the Government would not be as it were working altogether in the dark. Lessors have duties and responsibilities beyond the mere receipt of the rent, and when the Government stands in this position, it is more incumbent than ever that the State should carry out its duties to the full.

Mr. Williams suggests a twin or triple set of shafts, which for exploitation purposes would of course be necessary, but if the efforts of the Government were confined to prospecting and proving the ground, a single bratticed shaft would be all that was needed. Three well placed single shafts would be probably all that would be necessary to prove the whole of the doubtful ground known to exist at present on the Far East Rand. In case any or all of the ground adjacent to, or within reach of these shafts proved profitable, the shafts could always be used for ventilating purposes, and could therefore be of value to those working the payable areas. Judging from the prospecting work already carried out on the Far East Rand, in conjunction with the conclusions arrived at by Dr. Mellor, there should be no need for any of these Government prospecting shafts to be sunk east of a straight line drawn from Brakpan to the Nigel mine. West of such a line prospecting shafts sunk by the State would be necessary.

With regard to Mr. Williams' suggestion that elliptical shafts be sunk on the Far East Rand, it is far more probable that the circular shape would be preferred, not only because they would be stronger, but on the grounds of economy and efficiency. Circular shafts for deep mining are being more generally adopted than formerly on the Rand, and so is reinforced concrete for lining shafts and supports in deep mining. Seeing that the Far East Rand is essentially a deep-mining proposition, all these up-to-date suggestions will no doubt be largely considered in the future.

If we discard such doubtful properties as Holfontein, Geygerle, Droogefontein, Palmietkuil, and Reitfontein, all of which carry the sub-outcrop of the reef at a shallow depth and are therefore capable of being cheaply proved, there does not appear at present any need of State assistance in proving the properties lying east of a line drawn from Brakpan to the Sub-Nigel mine. All these properties are held by companies well able to find the necessary capital to work the mynpachts, and sink the necessary shafts, and no doubt this large area will be dealt with on somewhat similar lines to the two areas recently leased. It is when we come to consider the area lying west of this line that Government help would be necessary, for on such properties as Witpoort, Withoek, Vlakfontein, and Spaarwater, State aid in prospecting would be of material advantage.

VOGELSTRUIS.—This is a property in the western Rand, situated between Roodepoort and Bantjes, and like many other properties in that district its career has been chequered. Sir Donald Currie was at one time controller, and other well known names associated were Struben and Molteno. Conditions have been very unfavourable of late years, and the yield has not covered the working cost. In all probability operations will be suspended before long. While writing of this part of the Rand, it is interesting to record that a number of small properties are being worked in the break between Champ D'Or and Princess Estate. Four small mills are in operation there and a 20-stamp mill is being erected.

METAL MARKETS

COPPER.—The market has been firm, and official prices have been raised for cash standard from £134 to £140 and for electrolytic from £145–£142 to £151–£147. Prices here are nominal, as business has entirely passed into the hands of the Ministry of Munitions. As to America, demand absorbs the whole of the enormous production, and from 32½–33½ cents, electrolytic has risen to 36–36½ cents for early delivery and to 34–35½ cents for the second quarter of the year. Producers show reserve, both because they are well sold, and because the political situation renders this course advisable. Japanese shipments are increasing, but the freight difficulties from there are becoming formidable, chiefly because the submarine menace, in causing vessels to come home via the Cape, renders the voyage considerably longer. Sales of Japanese rough copper are reported to America.

Average prices of cash standard copper: February 1917, £138. 5s. 9d.; January 1917, £131. 16s. 9d.; February 1916, £102. 13s. 1d.

TIN.—Tin has been fairly steady, and official prices are still £199. 5s. for cash. The three months' price has risen to £199. 5s—£199. 10s. America continues to pay high premiums, and sales are recently reported at 51c. for Straits, while 48½c. has been freely realized for Banka. A scarcity of Straits warrants manifested itself in London during the month owing to delay in arrival of several homeward-bound cargoes. These have now come in, and deliveries have been made more freely. English tin has been scarce, and commands full premiums. It is understood that there has been a heavy demand on Government account. Shipments from the Straits have been disappointing owing to scarcity of freight, and stocks are accumulating there.

Average price of cash standard tin: February 1917, £198. 19s. 3d.; January 1917, £186. 6s. 4d.; February 1916, £181. 3s. 4d.

SPELTER.—Prices have been very steady at £56. 15s.–£53. 15s. Transport difficulties have interfered considerably with American imports, and with the supplies of ores to English works. Japanese dealers have, however, been active, and large supplies are reaching us from the East. American producers will only quote on an f.o.b. basis.

Average prices of good ordinary brands: February 1917, £54. 4s. 6d.; January 1917, £48. 8s. 3d.; February 1916, £93. 10s. 11d.

LEAD.—There is no movement in price to record on this market, the official quotation remaining £30. 10s.–£29. 10s. The American price has risen from 8 to 9 cents. Large quantities of lead are lying in Spain awaiting shipment, as tonnage is barely procurable.

Average prices of soft foreign lead: February 1917, £30; January 1917, £30; February 1916, £31. 18s. 9d.

NICKEL.—£225 per ton.

PLATINUM.—290s. per oz. In the United States the price is advancing again and is now about $110 per oz.

COBALT.—8s. per lb. CADMIUM.—8s. per lb.

QUICKSILVER.—The price has rapidly advanced, and after being firm at £20 per flask of 75 lb. is now "nominal." The American price has advanced to $100.

SILVER.—About the middle of February the price went up to 38½d.; since then the price has reverted to about 37½d. The supplies are not plentiful and the requirements for coinage continue high.

MOLYBDENITE.—105s. per unit 90% MoS_2.

WOLFRAM.—55s. per unit 70% WO_3.

No quotations for aluminium, antimony, or bismuth.

PRICES OF CHEMICALS. March 8.

Owing to the war, buyers outside the controlled firms have a difficulty in securing supplies of many chemicals, and the prices they pay are often much higher than those quoted below.

		£	s.	d.
Acetic Acid, 40%	per cwt.	2	15	0
,, 60%	,,	3	10	0
,, Glacial	,,	6	15	0
Alum	per ton	14	0	0
Alumina, Sulphate of	,,	18	10	0
Ammonia, Anhydrous	per lb.		1	9
,, 0·880 solution	per ton	32	10	0
,, Chloride of, grey	per cwt.	1	18	0
,, ,, ,, pure	,,	3	10	0
,, Nitrate of	per ton	65	0	0
,, Phosphate of	,,	85	0	0
,, Sulphate of	,,	15	10	0
Arsenic, White	,,	55	0	0
Barium Chloride	,,	30	0	0
,, Carbonate	,,	9	0	0
,, Sulphate	,,	5	10	0
Bleaching Powder, 35% Cl.	,,	29	10	0
Borax	,,	33	0	0
Carbolic Acid, 60% Crude	per gal.		3	6
China Clay	per ton	1	10	0
Copper, Sulphate of	,,	65	0	0
Cyanide of Potassium, 98%	per lb.		1	0
,, ,, Sodium, 100%	,,			10
Hydrofluoric Acid	,,			6
Iodine	,,		11	4
Iron, Sulphate of	per ton	4	15	0
Lead, Acetate of, white	,,	85	0	0
,, Nitrate of	,,	65	0	0
,, Oxide of, Litharge	,,	42	0	0
,, White	,,	47	0	0
Magnesite, Calcined	,,	15	0	0
Magnesium Sulphate	,,	10	10	0
Oxalic Acid	per lb.		1	7
Phosphoric Acid	,,			10
Potassium Bichromate	,,		1	4
,, Carbonate	per ton	110	0	0
,, Chlorate	per lb.		2	4
,, Chloride 80%	per ton	60	0	0
,, Hydrate, (Caustic) 90%	,,	300	0	0
,, Nitrate	,,	75	0	0
,, Permanganate	per lb.		12	6
,, Prussiate, Yellow (Ferricyanide)	,,		4	0
,, Sulphate, 90%	per ton	60	0	0
Sodium Metal	per lb		1	3
,, Acetate	per ton	70	0	0
,, Bicarbonate	,,	7	5	0
,, Carbonate (Soda Ash)	,,	7	0	0
,, ,, (Crystals)	,,	3	5	0
,, Hydrate, 76%	,,	24	0	0
,, Hyposulphite	,,	13	0	0
,, Nitrate, 95%	,,	23	0	0
,, Phosphate	,,	29	0	0
,, Silicate	,,	7	0	0
,, Sulphate (Salt-cake)	,,	2	2	6
,, ,, (Glauber's Salts)	,,	3	10	0
,, Sulphide	,,	21	0	0
Sulphur, Roll	,,	28	0	0
,, Flowers	,,	29	0	0
Sulphuric Acid, non-arsenical 140°T.	,,	4	5	0
,, non-arsenical 95%	,,	7	0	0
Superphosphate of Lime, 18%	,,	5	10	0
Tin Crystals	per lb.		1	4
Zinc Chloride, solution 100°T.	per ton	25	0	0
Zinc Sulphate	,,	24	10	0

STATISTICS.

Production of Gold in the Transvaal.

	Rand	Elsewhere	Total	Value
	Oz.	Oz.	Oz.	£
Year 1912	8,753,563	370,731	9,124,299	38,757,560
Year 1913	8,430,998	363,826	8,794,824	37,358,040
Year 1914	8,033,567	344,570	8,378,139	35,588,075
Year 1915	8 772,919	320,752	9,073,671	38,627,461
January 1916	759,852	27,615	787,467	3,344,948
February	727,346	26,248	753,594	3,201,063
March	768,714	27,975	796,689	3,384,121
April	728,399	26,273	754,672	3,205,643
May	751,198	26,483	777,681	3,303,377
June	735,194	26,570	761,764	3,235,767
July	733,485	27,602	761,487	3,232,891
August	752,940	28,210	781,150	3,318,116
September	744,881	26,686	771,567	3,277,408
October	764,489	27,850	792,339	3,365,642
November	756,370	26,696	783,066	3,326,253
December	748,491	25,971	774,462	3,289,705
Year 1916	8,971,359	324,179	9,295,538	39,484,934
January 1917	756,997	25,637	782,634	3,324,418

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
January 31, 1916	209,835	9,228	802	219,865
February 29	209,426	9.468	970	219,864
March 31	203,575	9,588	917	214,080
April 30	199,936	9,827	938	210,701
May 31	194,765	9,811	1,459	206,035
June 30	192,809	9,859	2,105	204,773
July 31	192,130	9,932	3,339	205,401
August 31	194,112	10,086	5,146	209,344
September 30	197,734	10,239	6.527	214,500
October 31	199,330	10,907	6,358	216,595
November 30	196,132	11,118	5,928	213,178
December 31	191,547	11,487	5,194	208,228
January 31, 1917	188,624	11,611	5,591	205,826

Cost and Profit on the Rand.

Compiled from official statistics published by the Transvaal Chamber of Mines. The profit available for dividends during 1915 was 63% of the working profit.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
Year 1912	25,486,361	29 2	19 3	9 11	12,678,095
Year 1913	25,628,432	27 9	17 11	9 6	12,189,105
Year 1914	25,701,954	26 6	17 1	9 0	11,553,697
Year 1915	28,314,539	26 3	17 5	8 5	11,931,062
January 1916	2,449,518	26 1	17 10	7 10	962,120
February	2,297,276	26 8	18 4	8 0	924,310
March	2,455,019	26 5	18 1	8 0	979,234
April	2,291,231	26 10	18 2	8 4	951,247
May	2,382,298	26 7	18 2	8 2	977,263
June	2,296,520	27 0	18 3	8 6	977,681
July	2,370,244	26 1	17 10	8 0	949,606
August	2,423,669	26 3	17 10	8 1	976,125
September	2,367,793	26 6	18 0	8 3	972,704
October	2,453,437	26 4	17 10	8 2	1,001,843
November	2,389,056	26 9	18 2	8 2	980,387
December	2,349,191	26 10	18 2	8 4	977,481

Production of Gold in Rhodesia and West Africa.

	Rhodesia.		West Africa.	
	1916	1917	1916	1917
	£	£	£	£
January	318,586	296,113	140,579	131,665
February	313,769	...	137,739	...
March	335,368	...	150,987	...
April	339,386	...	135,976	...
May	323,783	...	132,976	...
June	333,070	...	127,107	...
July	322,365	...	128,574	...
August	338,001	...	125,143	...
September	322,035	...	127,138	...
October	325,608	...	132,577	...
November	317,135	...	130,101	...
December	306,205	...	146,409	...
Total	3,895,311	296,113	1,615,306	131,665

Western Australian Gold Statistics.

	Reported for Export oz.	Delivered to Mint oz.	Total oz.	Total value £
January 1916	1,861	92,124	93,985	399,220
February	2,832	65,138	67,970	288,717
March	5,600	88,393	93,993	399,255
April	2,926	87,601	90,527	384,532
May	577	83,301	83,878	356,289
June	2,070	92,612	94,682	402,181
July	912	91,725	92,637	393,495
August	*	89,522	*	*
September	*	85,978	*	*
October	*	82,732	*	*
November	*	87,322	*	*
December	*	88,205	*	*
January 1917	*	83,962	*	*
February	*	81,810	*	*

* By direction of the Federal Government the export figures will not be published until further notice.

Australian Gold Returns.

	Victoria.		Queensland.		New South Wales	
	1916	1917	1916	1917	1916	1917
	£	£	£	£	£	£
January	89,900	...	66,700	50,150	39,000	29,000
February	76,500	...	79,050	...	30,000	26,000
March	103,600	...	76,920	...	36,000	...
April	60,000	...	83,300	...	63,000	...
May	119,500	...	116,230	...	19,000	...
June	86,000	...	72,200	...	18,000	...
July	100,600	...	85,400	...	23,000	...
August	66,800	...	86,000	...	24,000	...
Septem.	115,100	...	65,450	...	32,000	...
October	81,400	...	74,800	...	32,000	...
Novem.	94,000	...	60,300	...	31,000	...
Decem.	96,600	...	73,550	...	111,000	...
Total	1,090,000	...	940,500	50,150	459,000	55,000

Production of Gold in India.

	1914	1915	1916	1917
	£	£	£	£
January	193,140	201,255	192,150	190,047
February	185,508	195,970	183,264	180,904
March	191,853	194,350	186,475	...
April	189,197	196,747	192,208	...
May	193,031	199,786	193,604	...
June	192,224	197,447	192,469	...
July	195,137	197,056	191,404	...
August	196,560	197,984	192,784	...
September	195,843	195,952	192,330	...
October	198,191	195,531	191,502	...
November	197,699	192,714	192,298	...
December	211,911	204,590	205,164	...
Total	2,340,259	2,366,457	2,299,568	370,951

Daily London Metal Prices

Copper, Lead, Zinc, Tin, in £ per long ton. Silver in pence per standard ounce.

	Copper Standard	Copper Electrolytic	Copper Best Select'd	Lead	Zinc	Tin Standard	Silver
Feb.	£	£	£	£ s.	£ s.	£ s. d.	d.
12	138	147	145	30 10	56 0	200 5 0	$38\frac{1}{16}$
13	138	147	145	30 10	56 15	199 5 0	$38\frac{7}{16}$
14	140	149	145	30 10	56 15	199 10 0	$38\frac{1}{4}$
15	140	149	145	30 10	56 15	199 10 0	$38\frac{1}{4}$
16	140	149	147	30 10	56 15	197 15 0	$38\frac{1}{4}$
19	140	149	147	30 10	56 15	195 10 0	$38\frac{1}{8}$
20	139	150	148	30 10	56 15	194 10 0	38
21	139	150	148	30 10	56 15	195 5 0	$37\frac{3}{4}$
22	139	150	148	30 10	56 15	197 5 0	$37\frac{9}{16}$
23	139	150	148	30 10	56 15	197 5 0	$37\frac{3}{4}$
26	139	151	148	30 10	56 15	198 10 0	$37\frac{1}{2}$
27	139	151	149	30 10	56 15	200 15 0	$37\frac{1}{2}$
28	139	151	149	30 10	56 15	202 5 0	$37\frac{1}{2}$
Mar.							
1	139	151	149	30 10	56 15	199 15 0	$37\frac{1}{4}$
2	139	151	149	30 10	56 15	199 5 0	$37\frac{1}{8}$
5	139	151	149	30 10	58 10	200 5 0	$37\frac{5}{16}$
6	139	151	149	30 10	58 0	201 0 0	$37\frac{3}{16}$
7	139	151	149	30 10	56 10	202 5 0	$37\frac{3}{16}$
8	$137\frac{1}{2}$	151	149	30 10	55 10	201 10 0	$37\frac{1}{8}$
9	136	151	149	30 10	55 10	201 10 0	$37\frac{5}{16}$

Imports of Ores and Metals into United Kingdom.

These figures do not include Government imports.

Long tons.

	Dec. 1916	Year 1916	Jan. 1917
	Tons	Tons	Tons
Iron Ore	400,753	6,905,936	511,804
Copper Ore	3,386	34,492	1,949
,, Matte and Precipitate	2,178	43,839	2,091
,, Metal	9,076	111,412	7 981
Copper and Iron Pyrite	70,750	951,206	92,000
Tin Concentrate	1,849	33,912	1,497
,, Metal	1,632	33,646	2,213
Manganese Ore	19,905	439,509	32,047
Lead, Pig and Sheet	19,024	157,985	11,929
Zinc (spelter)	5,519	53,324	6,938
	lb.	lb.	lb.
Quicksilver	1,800	2,556,214	47,044

Exports of Copper from United States

Reported every month by the United States Customs.

1916	Long tons	1916	Long tons	1917	Long tons
January	21,863	July	35,048	January	25,540
February	20,548	August	34,700	February	21,937
March	24,006	September	28,572	March	—
April	19,980	October	32,712	April	—
May	14,700	November	21,433	May	—
June	38,277	December	21,438	June	—
		Total 1916...	313,277	Total 1917...	50,477

Outputs of Tin Mining Companies.

In Tons of Concentrate.

	Year 1916 Tons	Jan. 1917 Tons	Feb. 1917 Tons
Briseis (Tasmania)	467	34	...
Bisichi (Nigeria)	473	40	...
Dolcoath (Cornwall)	1,076	60	...
East Pool (Cornwall)*	1,012	88	...
Gopeng (F.M.S.)	1,113	92	76
Malayan Tin (F.M.S.)	1,104	65	62
Mongu (Nigeria)	576	60	60
Naraguta (Nigeria)	523	48	...
N. N. Bauchi (Nigeria)	578	45	...
Pahang (F.M.S.)	2,591	220	220
Rayfield (Nigeria)	658	50	50
Renong (Siam)	894	82	61
Siamese Tin (Siam)	906	81	...
South Crofty (Cornwall)*	700	55	55
Tekka-Taiping (F.M.S.)	651	47	30
Tongkah Harbour (Siam)	1,135	96	87
Tronoh (F.M.S.)	1,662	108	83

* Including Wolfram.

Stocks of Tin.

Reported by A. Strauss & Co. Long tons.

	Dec. 31, 1916	Jan. 31, 1917	Feb. 28, 1917
	Tons	Tons	Tons
Straits and Australian, Spot	1,990	1,659	907
Ditto, Landing and in Transit	750	835	2,020
Other Standard, Spot and Landing	1,550	1,252	995
Straits, Afloat	4,177	4,080	5,994
Australian, Afloat	330	370	450
Banca, on Warrants	—	—	—
Ditto, Afloat	2,578	1,955	1,918
Billiton, Spot	—	—	—
Ditto, Afloat	533	473	100
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	968	745	1,613
Afloat for United States	4,698	4,517	3,625
Stock in America	3,511	4,622	3,027
Total Stock	21,085	18,508	20,649

Shipments and Imports of Tin

Reported by A. Strauss & Co. Long tons.

	Year 1916	Jan. 1917	Feb. 1917	Total 1917
	Tons	Tons	Tons	Tons
Shipments from:				
Straits to U.K.	27,157	1,905	4,264	6,169
Straits to America	25,943	2,165	1,048	3,213
Straits to Continent	8,487	745	943	1,688
Australia to U.K.	2,537	239	95	334
U.K., Holland, and Continent to America	14,863	1,550	1,035	2,585
Imports of China Tin into U.K. and America	1,305	—	5	5
Imports of Bolivian Tin into Europe	15,116	527	2,968	3,495
Deliveries in U.K.	16,862	1,215	1,117	2,332
,, ,, Holland	943	105	85	190

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1912	1913	1914	1915	1916	1917
	Tons	Tons	Tons	Tons	Tons	Tons
January	204	466	485	417	531	648
February	240	427	469	358	528	...
March	247	510	502	418	547	...
April	141	430	482	444	486	...
May	144	360	480	357	536	...
June	121	321	460	373	510	...
July	140	357	432	455	506	...
August	201	406	228	438	498	...
September	196	422	289	442	535	...
October	256	480	272	511	584	...
November	340	446	283	467	679	...
December	310	478	326	533	654	...
Total	2,540	5,103	4,708	5,213	6,594	648

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters.

Long Tons.

	1913	1914	1915	1916	1917
	Tons	Tons	Tons	Tons	Tons
January	4,121	4,983	4,395	4,316	3,558
February	3,823	3,555	3,780	3,372	2,755
March	3,562	3,839	3,653	3,696	...
April	4,066	4,087	3,619	3,177	...
May	4,319	4,135	3,823	3,729	...
June	3,993	4,303	4,048	3,435	...
July	4,245	4,582	3,544	3,517	...
August	4,620	3,591	4,046	3,732	...
September	4,379	3,623	3,932	3,636	...
October	4,409	3,908	3,797	3,681	...
November	3,976	4,085	4,059	3,635	...
December	4,614	4,351	4,071	3,945	...
	50,127	49,042	46,767	43,871	6,313

Sale of Tin Concentrate at Redruth Ticketings.

	Long tons	Value	Average
Year 1915	4,918	£448,362	£90 14 6
July 3, 1916	179	£17,477	£97 12 10
July 17	186½	£17,114	£91 15 4
July 31	172¼	£16,172	£93 17 8
August 14	166	£15,955	£96 2 4
August 28	180¼	£17,345	£96 4 8
September 11	184	£17,113	£93 0 2
September 25	166½	£15,980	£95 19 7
October 9	197	£19,443	£98 13 11
October 23	170	£17,167	£100 19 9
November 8	194½	£19,701	£101 5 10
November 20	172	£18,044	£104 18 2
December 4	160½	£16,588	£105 4 6
December 18	186¼	*	*
Total, 1916	4,668	£478,194	—
January 2, 1917	176	*	*
January 15	160¾	£16,681	£103 15 5
January 29	152	£16,095	£105 17 10
February 12	182¼	£20,649	£113 6 1
February 26	176¾	£19,700	£111 9 3

* Prices not published.

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:

	Mar. 6, 1916 £ s. d.	Mar. 5, 1917 £ s. d.
Rand:		
Bantjes	12 9	7 6
Brakpan	3 15 0	4 11 3
Central Mining (£8)	6 0 0	6 7 6
Cinderella	6 0	4 6
City & Suburban (£4)	1 12 6	1 15 0
City Deep	3 13 9	4 2 0
Consolidated Gold Fields	1 6 3	1 7 6
Consolidated Langlaagte	1 10 6	1 5 0
Consolidated Main Reef	19 6	16 9
Consolidated Mines Selection (10s).	16 0	1 2 9
Crown Mines (10s.)	2 17 6	2 13 9
Daggafontein	12 6	13 6
D. Roodepoort Deep	14 6	11 3
East Rand Proprietary	17 9	11 0
Ferreira Deep	1 13 9	1 3 9
Geduld	1 15 6	2 1 6
Geldenhuis Deep	1 1 3	1 1 3
Gov't Gold Mining Areas	1 13 0	2 16 0
Heriot	2 10 0	2 7 6
Jupiter	7 3	6 9
Kleinfontein	1 8 0	1 3 0
Knight Central	17 9	9 0
Knight's Deep	1 2 6	1 1 3
Langlaagte Estate	19 0	16 3
Luipaard's Vlei	9 0	6 6
Main Reef West	8 6	3 6
Meyer & Charlton	5 6 3	5 1 3
Modderfontein (£4)	15 1 3	18 12 6
Modderfontein B	5 10 0	7 8 0
Modder Deep	5 10 6	6 13 9
Nourse	15 6	1 0 0
Rand Mines (5s.)	3 15 0	3 10 6
Rand Selection Corporation	2 14 6	3 8 0
Randfontein Central	10 0	11 6
Robinson (£5)	1 0 0	19 6
Robinson Deep	1 0 0	1 10 0
Rose Deep	1 6 3	18 0
Simmer & Jack	7 6	6 0
Simmer Deep	2 9	4 0
Springs	2 9 6	2 14 6
Van Ryn	2 0 6	1 17 6
Van Ryn Deep	3 0 0	3 2 0
Village Deep	1 13 0	1 7 0
Village Main Reef	1 1 3	14 0
Witwatersrand (Knight's)	2 15 6	2 7 0
Witwatersrand Deep	1 3 9	17 6
Wolhuter	10 3	10 0
Other Transvaal Gold Mines:		
Glynn's Lydenburg	10 6	15 0
Sheba (5s.)	2 6	1 3
Transvaal Gold Mining Estates	1 3 0	1 0 0
Diamonds in South Africa:		
De Beers Deferred (£2 10s.)	11 0 0	12 15 0
Jagersfontein	3 5 0	4 7 6
Premier Deferred (2s. 6d.)	4 12 6	7 10 0
Rhodesia:		
Cam & Motor	11 6	9 6
Chartered British South Africa	10 6	11 6
Eldorado	9 9	8 6
Falcon	9 0	14 9
Gaika	11 6	8 9
Giant	6 3	6 0
Globe & Phœnix (5s.)	1 1 6	1 10 0
Lonely Reef	1 2 8	1 6 9
Shamva	1 14 6	1 2 0
Wanderer (3s.)	1 0	1 0
Willoughby's (10s.)	5 0	4 0
West Africa:		
Abbontiakoon (10s.)	7 9	4 6
Abosso	10 0	7 0
Ashanti (4s.)	18 9	18 6
Prestea Block A	8 0	6 0
Taquah	19 0	16 6
West Australia:		
Associated Gold Mines	5 3	3 0
Associated Northern Blocks	4 3	2 9
Bullfinch	5 3	2 3
Golden Horse-Shoe (£5)	1 18 9	1 13 9
Great Boulder Proprietary (2s.)	14 9	11 3
Great Boulder Perseverance	1 0	1 3
Great Fingall (10s).	2 6	1 0
Ivanhoe (£5)	2 3 9	2 0 0
Kalgurli	11 3	8 6
Sons of Gwalia	15 6	13 9

Gold, Silver, *cont.*	Mar. 6, 1916 £ s. d.	Mar. 5, 1917 £ s. d.
Others in Australasia:		
Mount Boppy, New South Wales	15 0	5 0
Talisman, New Zealand	15 0	7 6
Waihi, New Zealand	1 15 0	1 14 6
Waihi Grand Junction, New Z'lnd	18 9	16 0
America:		
Alaska Treadwell (£5), Alaska	6 12 6	2 10 0
Buena Tierra, Mexico	13 9	8 6
Camp Bird, Colorado	7 0	5 6
Canadian Mining, Ontario	9 0	15 9
Casey Cobalt, Ontario	3 6	6 0
El Oro, Mexico	8 0	7 6
Esperanza, Mexico	10 0	8 3
Frontino & Bolivia, Colombia	9 3	13 0
Le Roi No. 2 (£5), British Columbia	12 6	10 0
Mexico Mines of El Oro, Mexico	3 15 0	4 10 0
Oroville Dredging, California	13 6	15 6
Plymouth Consolidated, California	18 0	1 1 3
St. John del Rey, Brazil	15 0	15 0
Santa Gertrudis, Mexico	10 6	8 9
Tomboy, Colorado	1 1 6	1 0 0
Russia:		
Lena Goldfields	1 15 0	2 1 3
Orsk Priority	16 3	1 3 9
India:		
Champion Reef (2s. 6d.)	7 9	5 9
Mysore (10s.)	4 2 0	3 0 0
Nundydroog (10s.)	1 7 6	1 6 0
Ooregum (10s.)	1 5 6	1 0 0

COPPER:

	Mar. 6, 1916 £ s. d.	Mar. 5, 1917 £ s. d.
Anaconda (£10), Montana	18 5 0	17 10 0
Arizona Copper (5s.), Arizona	1 18 9	2 7 6
Cape Copper (£2), Cape Province	3 2 6	4 2 6
Chillagoe (10s.), Queensland	6	3
Cordoba (5s.), Spain	4 3	3 6
Great Cobar (£5), N.S.W.	4 0	2 0
Hampden Cloncurry, Queensland	1 18 9	1 14 3
Kyshtim, Russia	1 18 9	2 11 3
Messina (5s.), Transvaal	11 3	10 0
Mount Elliott (£5), Queensland	3 0 0	5 10 0
Mount Lyell, Tasmania	1 8 0	1 5 3
Mount Morgan, Queensland	2 2 6	1 10 6
Rio Tinto (£5), Spain	61 0 0	61 15 0
Sissert, Russia	1 1 3	1 7 0
Spassky, Russia	1 19 6	2 1 3
Tanalyk, Russia	1 15 0	2 5 0
Tanganyika, Congo and Rhodesia	1 19 6	2 7 0

LEAD-ZINC:

	Mar. 6, 1916 £ s. d.	Mar. 5, 1917 £ s. d.
Broken Hill:		
Amalgamated Zinc	1 8 6	1 9 6
British Broken Hill	1 7 0	1 6 9
Broken Hill Proprietary (8s.)	3 0 3	2 5 0
Broken Hill Block 10 (£10)	17 0	1 2 0
Broken Hill North	2 10 0	2 6 9
Broken Hill South	8 0 0	8 5 0
Sulphide Corporation (15s.)	1 2 0	1 4 9
Zinc Corporation (10s.)	14 6	15 6
Asia:		
Burma Corporation	1 16 0	3 17 6
Irtysh Corporation	1 14 6	2 4 3
Russian Mining	13 6	1 2 0
Russo-Asiatic	4 15 0	5 18 9

TIN:

	Mar. 6, 1916 £ s. d.	Mar. 5, 1917 £ s. d.
Aramayo Francke, Bolivia	1 7 6	1 11 3
Bisichi, Nigeria	6 3	10 9
Briseis, Tasmania	5 0	4 9
Dolcoath, Cornwall	7 6	8 6
East Pool, Cornwall	19 6	1 15 0
Ex-Lands Nigeria (2s.), Nigeria	1 6	1 6
Geevor (10s.) Nigeria	—	10 0
Gopeng, Malay	1 11 3	1 10 0
Ipoh Dredging, Malay	19 0	13 9
Malayan Tin Dredging, Malay	1 15 0	1 17 6
Mongu (10s.), Nigeria	8 9	9 6
Naraguta, Nigeria	18 9	13 0
N. N. Bauchi Pref. (10s.), Nigeria	2 3	7 6
Pahang Consolidated (5s.), Malay.	9 0	9 6
Rayfield, Nigeria	4 0	6 6
Renong Dredging, Siam	1 8 9	2 1 3
Ropp (4s.), Nigeria	13 9	16 6
Siamese Tin, Siam	2 15 0	2 7 6
South Crofty (5s.), Cornwall	8 3	16 3
Tekka, Malay	2 13 9	3 0 0
Tekka-Taiping, Malay	2 5 0	3 0 0
Tronoh, Malay	1 13 9	1 5 0

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

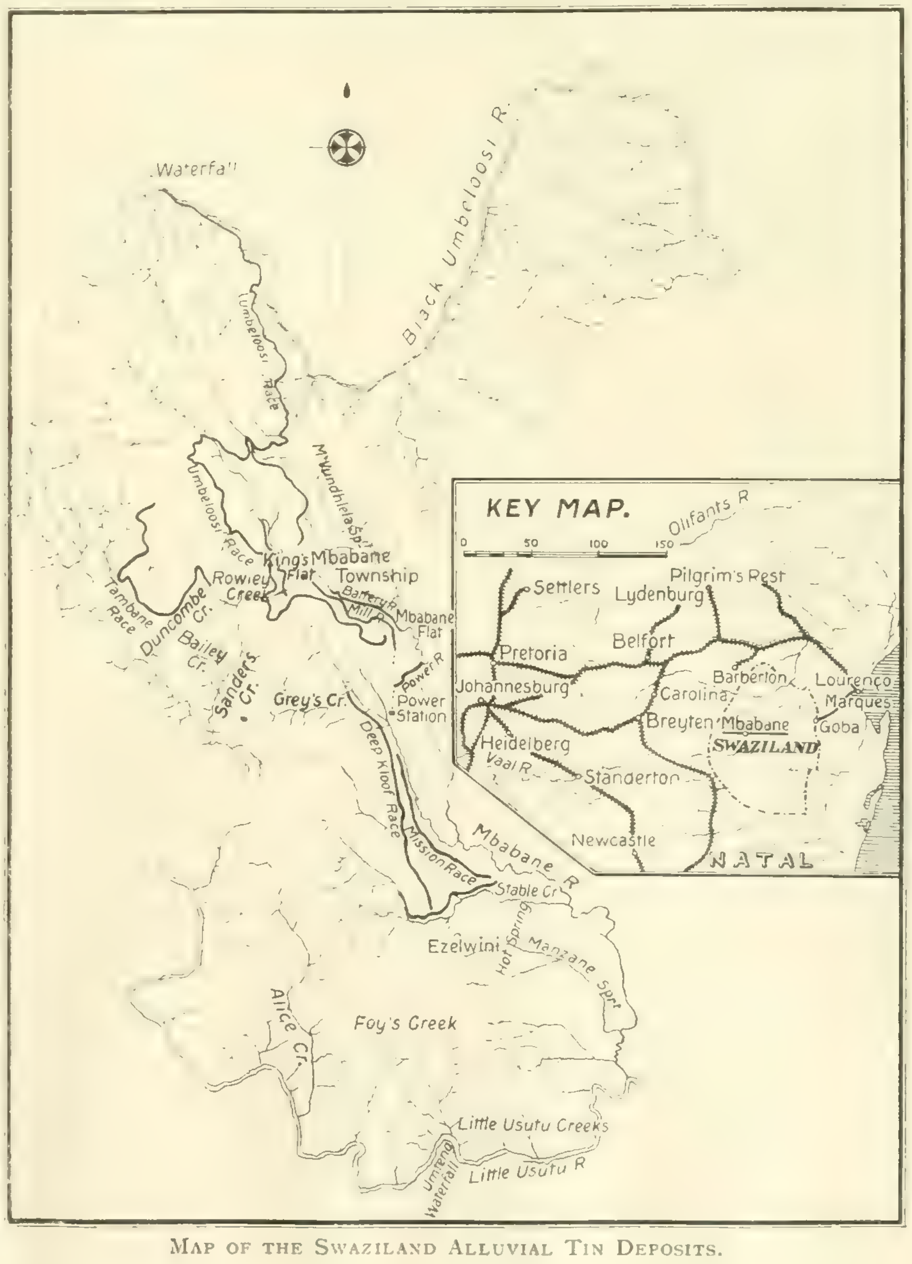
In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also reviews of new books, and abstracts of the yearly reports of mining companies.

MINING THE SWAZILAND ALLUVIAL TIN DEPOSITS.

At the February meeting of the Institution of Mining and Metallurgy a paper was presented by J. Jervis Garrard on "Hydraulic Tin Mining in Swaziland." The deposits are at Mbabane, and the concession was originally granted in 1887. In the early days the ground was worked on tribute. When the owners, Swaziland Tin Limited, started work on their own account in 1906, ground sluicing was adopted. In 1908 monitors were introduced for removing overburden. In 1911 hydraulic elevators were adopted in order to treat the deeper parts below water-level. The author was appointed consulting engineer in 1912, and he decided to add gravel pumps, and to provide the necessary power by erecting a hydro-electric station at the Mbabane Falls.

The tin gravel occurs in flats and in stream beds, and has been derived from the weathering of pegmatite veins in the granite of the bedrock. The chief flat deposit is covered by a soft overburden averaging 6 to 25 ft. thick containing a little tin, and consists of a bed 6 in. to 3 ft. thick of coarse tin-bearing gravel. This bed rests on the granite, which is so much decomposed that a foot of it is washed down with the gravel. There are also a large number of creek deposits both above and below the flats. The creek deposits are worked by ordinary sluicing and as there is sufficient fall, no difficulty is experienced in disposing of the tailing. The upper creeks are 4,000 to 5,000 ft. and the lower creeks 2,000 to 2,500 ft. above sea-level. Below the upper creeks are the flats where conditions are such that the tailing has to be elevated; these are from 3,500 to 4,000 ft. above the sea. There are other flats farther below, near the lower creeks.

The annual rainfall averages about 50 in. The chief supply of water to the hill creeks, from Ntamban Spruit, is taken high up in the mountains, and carried in a water-race seven miles long, through one tunnel, to a series of storage dams, from which it is distributed to the various creeks in subsidiary races. The amount of this water is about 225 cu. ft. per minute in the wet season, diminishing to about 20 cu. ft. in the dry season. The main supply to the flats is from the Mbabane river, which only rises about two miles above the upper working, and is supplemented by water taken out of the Mbelusi river and brought by a race 14 miles in length to the main upper flats, where it is delivered under a head of 150 to 300 ft. The full capacity of this race is about 1,000 cu. ft. per minute. More than 800 cu. ft. is rarely delivered during the wet season, while during the dry season this falls off to 300 cu. ft. The water is utilized to the utmost extent. It is first used under pressure in monitors to break ground in the Upper Mbabane Flat and King's Flat. After settlement in the big paddocks already worked out, it is caught up by another race and taken for use under pressure in monitors to break ground lower down at the Mbabane Flats. After settling it is caught up at the head of the Mbabane Falls and carried in a short race to the head-box of a pipeline 2,000 ft. long, where a portion of it is delivered under an effective head of 500 ft. to a Pelton wheel direct-coupled to an electric generator, which supplies the power necessary to drive the three



MAP OF THE SWAZILAND ALLUVIAL TIN DEPOSITS.

gravel pumps. These elevate the gravel, which this same water has already broken down. After leaving the tail race of the Pelton wheel, the water, together with the overflow from the head box, is taken by another water-race four miles farther on to Stable creek, where it is again used for breaking ground, and for elevating the ground by means of a hydraulic elevator. Thus the same water is used three times over for breaking fresh ground, and once for generating the power required to elevate the ground it has already broken.

In May 1911 systematic drilling of the various flats ahead of existing workings by means of Empire drills was instituted with a view to arriving at some idea of the extent and value of the ground remaining to be worked. Up to June 30, 1915, 2,341 holes had been drilled with a footage of 30,503 ft., costing 11¾d. per ft., including all transport. Recently the cost has been reduced to 5½d. per ft. At the above date 1,822,984 cu. yd., showing an average value of 1·44 lb. metallic tin per yard, was proved ahead of existing workings, in addition to 2,597,000 cu. yd. of ground in hill creeks estimated from results of past work (the ground being too bouldery for drilling) to be worth 0·69 lb. metallic tin per cu. yd., thus making a total of about 4,420,000 cu. yd. of an estimated average value of 1 lb. metallic tin per cu. yd. practically assured There is a further extent of tin-bearing ground amounting to 5,000,000 cu. yd., of which the value has not yet been proved.

Altogether six methods of working the gravels are employed, namely: Ground sluicing, hydraulicking under natural head without elevating, hydraulicking and gravel pumping, nozzle pumping and gravel pumping, nozzle pumping without elevating, hydraulicking and hydraulic elevating. In the following paragraphs we extract the gist of Mr. Garrard's experience.

Ground sluicing is employed only to a limited extent in places where no water or not sufficient water under pressure is available for hydraulicking. Such places occur chiefly in the upper portions of the hill creeks and on the slopes of the hills flanking creeks, where alluvial or "terrace" tin is found.

Hydraulicking under natural head without elevating is done in the following hill creeks: Sanders, Bailey, Duncombe, Bowley, and Foy's, and it is only during the wet season of the year that this is possible.

Hydraulicking and gravel pumping is the principal method in vogue. It is employed at the upper and lower Mbabane Flats and at King's Flat. The method employed is as follows: The water from the main Mbelusi race is led along the slopes of the hills which flank the flats at a level of from 150 to 275 ft. above the bed of the valley. At a convenient point in the race opposite the position of the working a head box is constructed from which a pipeline consisting of 12 to 22 in. pipes is laid down the hill slope to the working paddock. Branch pipes are taken off from the lower end of the main line and led, as convenience dictates, to the different working faces, where the water is used through monitors to break down the face of the paddock and banks. The pressure at the nozzles varies from about 55 to 110 lb. per sq. in., 2 to 2½ in. nozzles being used. The ground thus broken down is led into a temporary race in the bedrock to the sump of the gravel pump. If the fall is slight a monitor is used to blow the gravel to the sump. A few natives fork out of this race some of the larger stones and small boulders. The gravel pump direct-coupled to its motor rests on a pontoon 20 ft. square. This when at work rests on the bedrock. A movable suction pipe takes the gravel from the sump and the delivery pipe discharges it at an angle of some 45° into a launder, supported on trestles, which leads to the sluice-boxes placed at a convenient point on the bank above the general surface level. The height lifted is from 38 to 40 ft. The launder usually discharges on to an inclined grizzly over the head of the sluice-box, the over-size, consisting of stones and small boulders, being delivered direct into a truck which is trammed to the dump. The undersize falls into the head of the sluice-box, which varies from 8 to 11 ft. in width and 80 to 100 ft. in length, set to a grade of 1 in 25, and constructed of steel plates bolted together. The side plates, 3 ft. high, have angle-iron slots at intervals of 8 ft. into which 3 by 3 in. deals are dropped to form riffles.

The amount of gravel elevated averages 24 cu. yd. per hour, the amount of water pumped varying from 190 to 230 cu. ft. per minute. Additional water, not under pressure, is usually led in the head of the sluice-box to assist in sluicing the gravel through the box. Six or eight natives are constantly employed in the upper half of the sluice-box, loosening the gravel with forks and maintaining an even surface. As the bed of gravel accumulates in the box it is thinned down by stopping the supply of fresh gravel, and the rough concentrate from the upper portion of the box is shovelled out to the side periodically. At the close of each month the box is completely streamed down, the gravel from the lower part of the box being continually shovelled up the box against the stream of water, when the remaining concentrate is finally shovelled out. The rough concentrate thus produced is streamed down in small boxes about 16 ft. long by 18 in. wide, by natives constantly shovelling it up against the stream. Three natives are employed on each box, and they can treat from 12 to 15 tons per day according to the richness of the rough concentrate handled. This process brings the concentrate up to a grade of about 60% metallic tin, in which state it is sent to the central dressing plant.

The average labour complement for each gravel pump working is 55 natives and one European overseer for 24 hours. It was necessary to have a European overseer on each shift at the start and for some months after; but gradually it became possible to train natives to do the whole work efficiently. In fact, one European overseer has been able to look after two gravel pumping plants half-a-mile apart for several months past. Each plant is equipped with electric light for night work, and is in telephonic communication with the power station and with the mechanical staff.

When it is desired to shift the pontoon to a new site nearer the working face, a cut is made in the face of the paddock near the new site for the sluice-box. This cut is made just wide enough to allow the pontoon to pass. When the new site for the pontoon is reached, the cut is widened and the site levelled and beaconed off with long poles. The whole paddock is then flooded to a depth sufficient to enable the pontoon to be floated through the cut to its new position. This being accomplished, a sod dam is built behind the pontoon across the narrow cut, and a water lifter is used to pump out the water in this small paddock now formed. The pontoon then settles on the new site prepared for it and work is resumed. By this method much time is saved that would otherwise be spent in pumping out 3 ft. of water from the whole area flooded. Another sluice-box has, in the meantime, been constructed in a convenient position for the new site, and alterations or extensions to the power line and pipe-

No. 2. Gravel Pump at King's Flat.
The Monitor is blowing down Gravel to the Sump.

lines have been made in anticipation of the removal.

It occasionally happens that owing to physical conditions, such as the great difference of level, or the necessity of removal to a site too far away to make flotation possible, it becomes necessary to dismantle the whole plant, transport it to the new site and re-erect it there. The time lost over such an operation is about 20 days, and the cost amounts to about £250.

The general policy adopted in this class of work is always to operate up stream as far as possible, allowing the tailing to fill up the previously worked out paddocks. It may sometimes happen, however, that circumstances dictate the advisability of working down stream to a small extent. In that case, if there is still workable ground below, it becomes essential to arrange matters so that the tailing shall not be allowed to cover up this ground either by conducting the tailing in a race cut specially to by-pass it beyond the workable ground below, or by selecting some position of unworkable ground, if it exists, building a rough dam round it, and conducting the tailing into this dam.

The total cost of working by this method, including head office charges, amounts to 8·229d. per cu. yd., which includes 0·482d. per cu. yd. for power.

The nozzle pumping and gravel pumping method of working has been employed in the case of one gravel pump at Mbabane Flats working portions of four months of the dry season, when there was insufficient water under natural head available at this point to supply the gravel pump. The method employed is as follows: A two-stage centrifugal pump, direct-coupled to a 100 hp. motor, is mounted on the same pontoon as the gravel pump. It takes its suction from the creek water in the cut which diverts it from the paddock, and delivers 115 cu. ft. per minute through a 1¾ in. nozzle at a pressure of 100 lb. This pressure water serves the same purpose in breaking down the ground that the water under natural head does when that water is available, and the general arrangements and method of working are exactly the same as those just described. The power consumed by this nozzle pump amounts to about 68 units per hour. The cost of working by this method is practically the same as in the case of hydraulicking and gravel pumping. The method possesses many advantages if cheap power is available. It often saves the construction of new races, and the laying and constant shifting of long pipelines frequently in difficult positions, even when high pressure water under natural head is available; while, as will be seen, it is invaluable when this is not available. It is, in fact, probably preferable in certain cases to employ high-pressure water under natural head at one permanent point for the generation of power, and to utilize such power for the purpose of carrying out this method of working; its convenience is largely due to everything being concentrated in one self-contained unit which is floated from place to place.

Nozzle pumping without elevating has been employed high up in the hills in one of the creeks, at which point tin-bearing gravel was found to exist where no water under sufficient natural head could be spared for hydraulicking. The method employed is as follows: A dam is constructed across the creek below the working, with arrangements to enable the accumulation of tailing to be sluiced out periodically. One or more subsidiary settling dams connect with this to enable comparatively clear water to pass to the suction of a two-stage centrifugal pump driven by a 100 hp. motor. The pump delivers about 74 cu. ft. per minute, through a 1½ in. nozzle at about 75 lb. pressure, that at the pump being 85 lb. The length of the delivery varies from 200 to 600 ft. from the pump, and the height from 15 to 25 ft. above the pump. The gravel is broken down by this pressure water as in the case of natural hydraulicking, the tailing settling in the lower dam, until sluiced out at intervals, and the water being returned to the pump suction. About 7,000 cu. yd. has been cut per month at a cost of 9d. per cu. yd., actual creek cost, or 11d. per cu. yd., total cost. The average rate of cutting is about 21 cu. yd. per actual hour run, the power consumption being about 60 units per hour, equivalent to a duty of about 0·35 cu. yd. cut per unit.

The natural flow in the creek itself is about 20 to 30 cu. ft. per minute, but as it is always endeavoured to maintain a more or less constant flow of thick pulp of tailing water by the bottom outlet through the dam wall, the whole of this natural flow does not represent the true amount of make-up water used. If the configuration of the surface permitted it, the sluicing-out of the tailing would not be necessary, as the extent of the dam would then be simply enlarged and its depth increased, or another dam constructed higher up the creek, which would put a suction head on the nozzle pump. This method of working has also been successfully used by the author at the Groenfontein tin mines in the Waterberg district of the Transvaal, with the difference, however, that the make-up of water had to be pumped four miles and lifted about 1,200 ft.; the hydraulicking being carried on at the top of a hill by means of a seven-stage centrifugal nozzle pump circulating the water at that elevation, and the power being derived from a gas engine and bituminous gas plant at a cost of 0·65d. per unit.

Hydraulicking and hydraulic elevating is carried on at Stable creek, the lowest working on the property. The water from the upper gravel-pump workings after generating electric power at the power station is caught up in a race and carried four miles along the hill-side to a point opposite this working, when it is conducted down a pipeline which leads a portion of it to one or more monitors, and the balance to the hydraulic elevator. About 212 cu. ft. per minute at a pressure of 55 lb. is employed for breaking the ground. The height of the bank averages about 18 ft. The broken ground falls to the sump of the 12 in. elevator, which takes about 330 cu. ft. per minute at 55 lb. pressure, the average size of jet being 3·47 in. and average diameter of throat 6·55 in. The average height lifted is 23·3 ft., the 12 in. delivering pipe discharging into a sluice-box 11 ft. wide, 100 ft. long, set to a grade of 1 in 30. The amount of ground elevated averages 24·4 cu. yd. per hour, and the total volume of water used amounts to 1,302 cu. ft. per cu. yd. of ground removed, of which 490 cu. ft. is required per cu. yd. of ground broken down by monitors, so that the elevator consumes 62·2% of the available water, under 55 lb. pressure, for its operation, leaving only 37·8% available for breaking ground. As, however, there is more water available here than is required to do the work, its inefficient use is not of moment. Given a surplus of water under pressure, there is nothing to touch this device, but it is most wasteful otherwise. The total cost of working by this method, including head office charges, amounts to 6·276d. per cu. yd. This compares with 8·229d. for gravel pumps, but it should be mentioned that over the period in question the hydraulic elevator was working principally in deep, soft virgin soil, whereas the gravel pumps worked ground from which most of the material had been washed away in previous years. Given the same ground, it is probable that gravel pumping would not cost more than 6d. per yard, as the capacity of the pumps is greater.

THE WAVE-TRANSMISSION ROCK-DRILL.

A year or more ago a new type of rock-drill, known as the Haddon, was privately exhibited in London. The design is founded on the principle of wave-transmission through water in pipes, developed by a Roumanian engineer, Gogu Constantinesco. Since that time the drill has been tried in South Africa. Eustace M. Weston, of Randfontein, gives some account of it in the *Engineering and Mining Journal* for December 30. The English patents, numbered 9,029 of 1913, 12,438 of 1914, and 4,349 of 1915, cover this method of transmitting power. The principle employed is the compressibility of water, which though very small can be utilized advantageously in transmitting power. Water is contained in a pipe and kept at a pressure of 100 lb. per square inch. The pipe is connected at one end with a chamber in which a plunger is driven rapidly from a cam shaft, and at the other end with a motor. The plunger in its short stroke compresses the water in the chamber to bring its pressure up to 500 or 1,000 lb. per square inch. The wave of compression travels rapidly along the pipe and operates the plunger of the motor. Its speed is the same as that of the wave of sound, 4,800 ft. per second. By means of floating pistons with different diameters, the pressure of transmission may be transformed, and in this way power may be tapped at any point of the pipe line into branch pipes. In order to provide against unduly high pressures when the motors are cut off, condensers consisting of spherical chambers are placed at various parts of the pipe line. These are in open communication with the pipe line and are filled with water at the same pressure, and this water serves to absorb the "resonance." Fig. 1 shows diagrammatically the arrangement of the plant when used in distributing power throughout a machine shop or other works. Fig. 2 shows a rock-drill, designed on this Constantinesco principle by John Haddon.

The Haddon drill is a piston machine and is in outward appearance similar to an air-operated drill, except that there is no valve and that no valve chamber is apparent. It consists of a piston mounted between a rear and a front bearing, and floating between a strong spring on the front and a weaker one on the back. The rear of the piston is cut for the ratchet and enters a rear chamber containing pawl and ratchet for giving rotations. This chamber is full of water connected with the power line by a hose. The wave of compression sweeps into this chamber and forces out the piston against the spring, which brings it back on the return stroke, the return being governed by the rear spring. The drill has few moving parts. The introduction of springs has been criticized, but it would be easy to arrange the return stroke by wave motion. Tests, however, show that satisfactory

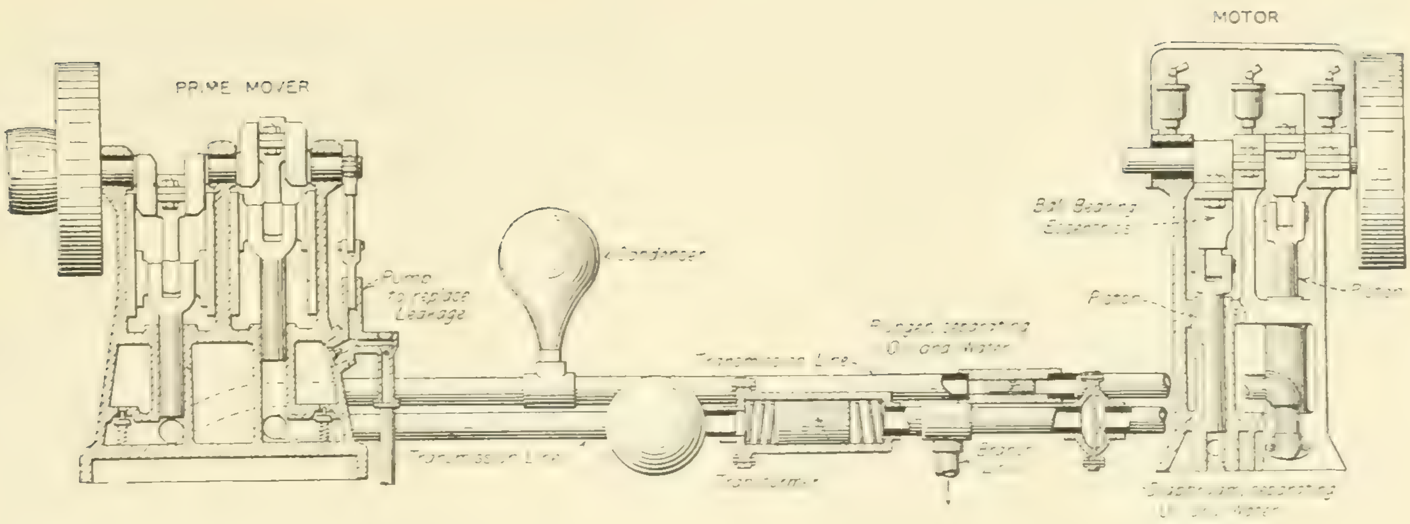


FIG. 1. DIAGRAMMATIC SKETCH OF WAVE-TRANSMISSION OF POWER.

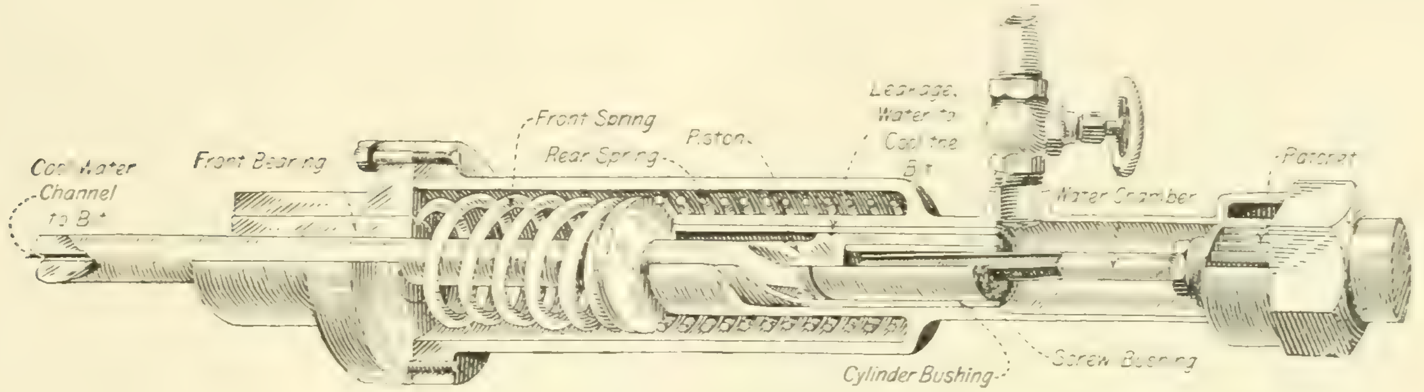


FIG. 2. ROCK-DRILL OPERATED BY WAVE-TRANSMISSION SYSTEM.

springs having a long life can be procured, and they are easily changed if necessary. The length of stroke is controlled by opening or closing the cock, but apart from the momentum of the piston and tool being decreased by the shorter stroke, the strength of the blow remains the same. This allows holes to be rapidly collared on a very short stroke. A positive mechanical revolution is being introduced into later designs of the drill, brought about by an auxiliary piston panel acting as a floating ratchet disk on the piston. This will be an important point in any hammer-drill model. Mining engineers may ask whether the return stroke of such a drill will be weak, causing constant fitchering. It is reported that trials show that fitchering rarely occurs, owing to the constant tugging action due to the repeated blows of the wave motion going on whether the drill be struck or not, and that this is a most marked feature of the drill. Another question is whether with such high pressures leakage will not be excessive. Only long underground experience will prove whether this consideration will be vital. It is easy to calculate that a certain percentage of leakage can be allowed without vitally impairing the efficiency of the system. The drill can be used with either solid or hollow steel, and naturally the system lends itself to the use of hollow steel and water injection. The latest type is designed to strike 1,000 blows of a force of about 40 to 50 ft.-lb. and weighs only about 180 lb. The original design struck 500 blows a minute, and showed itself a rapid driller. Mr. Weston has long held the opinion that the ideal drill for really hard work is not the hammer drill, but that if a piston drill could be designed to work on a very short stroke and to strike 1,000 blows or more per minute and deliver water under pressure to the drill bit, it would prove the ideal tool. The Haddon drill in varying forms is now being subjected to tests on the Rand, and the results are awaited with interest.

PUMP DREDGES VERSUS BUCKET DREDGES.

In our January issue we quoted at length from a paper read by A. C. Perkins before the Chamber of Mines of the Federated Malay States describing the conditions with regard to bucket-dredging for tin. In the discussion which followed, both at the meeting and by correspondence, many interesting facts and arguments were brought forward, notably by J. Malcolm Newman, of the Larut company, and T. R. A. Windeatt, of the Tekka-Taiping company. We quote some of their remarks, from the report contained in the *Magazine* of the Chamber of Mines.

Mr. Newman, though manager of bucket-dredging operations, expressed himself as a devotee of pump-dredging, explaining the apparent discrepancy by the fact that his company's bucket-dredge was ordered before he was appointed to the position of consulting engineer. He considered that in difficult ground, and one having an irregular bedrock, the gravel-pumping method made it possible to thoroughly clean the tin out of the crevices in a way that could not be done with a bucket. Also the ground that was cut from a bank by a powerful jet, forced down a sluice with a flow of water, and then taken and further disintegrated by the runner of a gravel pump, would be much more likely to yield a higher percentage of its contents, particularly when delivered to wide stationary sluice-boxes, than would be the case with the comparatively merciful treatment such ground receives in the bucket dredge. Gravel-pump dredging men believed that under conditions often found in the Federated Malay States they would get 1½ lb. of tin with a suction dredge out of so-called 1 lb. bucket-dredge ground.

In his report to the Larut Tin Dredging Ltd., Mr. Newman had called attention to the low recoveries of bucket dredges treating alluvial tin. He stated then that "good Australian practice in tin-sluicing by gravel-pumping provides about 1 ft. width of sluice-box for every two yards per hour of material treated." In this connection he pointed out the following facts :

(*1*) In gravel-pumping the distribution of feed to sluice-boxes is perfect. The amount of material sluiced per foot width of boxes does not vary as in bucket-dredging, where, even when a proper average sluicing rate is provided, the maximum and minimum rates vary enormously.

(*2*) During most of the time the material sluiced in a gravel pump contains very little tin, which is concentrated in the paddock and only blown-in and elevated at long intervals.

(*3*) The slope of the boxes does not alter as the boxes get full.

(*4*) The boxes are usually twice as long as in a bucket dredge.

(*5*) Each box is of great width, thus avoiding the eddy and swirl which occurs along the numerous divisions in the bucket-dredge sluices.

The above are the advantages of the pump-dredge sluice-boxes. Mr. Newman's predilection for gravel pumping is, however, based chiefly on its better work in the paddock in disintegrating the gravel and cleaning the bottom, and in making the face and bottom visible to the eye. An important advantage of this latter condition is that the yardage treated can be measured accurately, an impossibility in bucket-dredging, especially with limestone or other uneven bottom. A further advantage of the dry paddock is the facility for examining and sampling the face and comparing tin contents with the yield of tin.

In replying to Mr. Newman, Mr. Perkins expressed total disagreement from his remarks about the capabilities of the gravel pump as compared with the bucket dredge. He did not agree with the point that the hydraulic giants used in connection with the gravel pump were able to clean out the crevices of difficult bedrock. In his opinion it is very difficult to clean up rough bedrock with a nozzle, and it often happened that attempts to do so result in driving the tin further into the crevices, and the only way to recover this tin would be for coolies to scrape it out by hand or otherwise.

Mr. Windeatt discussed some of the causes of losses on the bucket dredge. These losses may be classified thus :

(*a*) Mining losses : (1) Failure of the bucket to raise all the valuable material ; (2) Valuable material spilt from the buckets ; (3) Valuable material failing to enter the drop chute or save-all.

(*b*) Treatment losses : (4) Valuable material lost from the screen down the tail chute ; (5) Valuable material passing over the ends of the boxes.

(*a1*) In the Taiping district, where the bedrock is of clay, the loss under this heading should be considerably less than in Kinta with an irregular limestone bottom. This loss is high with a careless or inexpert winchman. Generally the native winchman thinks more of getting the stop down than of getting the last yard of tin-bearing ground from the bedrock. There is little doubt that this loss can be reduced by careful continuous European supervision.

(*a2*) With a well designed bucket the losses through spilling should not be serious, unless the buckets are over full. This is not a common fault in the Federated Malay States.

(*a3*) If the hopper and save-all are well designed, and if the buckets tip well, there should be little or no loss under this heading.

(*b4*) The greatest losses occur from the screen, which is expected to perform two distinct operations ; first, to disintegrate the material raised (with the assistance of water) and prepare it in a condition for screening ; and, second, to pass the fine and valuable material through the screen holes on to the tables, and to reject the over-size in the shortest possible time.

The screens in use may be roughly divided into two classes ; first, those using high-pressure water, as at Malayan Tin, where the sparge-pipe carries pressure jets, and at Ipoh Tin where a monitor, placed at the end of the screen is directed on to the material in the screen ; high-pressure water from the sparge-pipe is more satisfactory than a jet from a monitor, as the latter causes uneven wear of the screen-plates and interferes with regular distribution of material to the boxes. Second, on other dredges only low-pressure water is used in the screen. Longitudinal bars inside the trommel, as at Tekka Taiping, or stopped screens as at Trong and Larut, are depended upon to break up the material. When on a visit to Tekka Taiping, Mr. Perkins mentioned an interesting point against longitudinal bars set in the screen. A sliding action between the material and the screen-plates is the ideal for efficient screening. Bars, placed inside the screen, which give a rotary motion to the material, detract from the efficiency of the screen as a sizing machine. It is found, however, that the bars carry the material around toward the highest point of the screen, thus increasing the arc of contact between the screen-plates and the material in the screen, and consequently they increase the effective screening area.

There is considerable diversity of opinion upon the best size of the holes in the screen. If the present type of screen in retained it must necessarily be a compromise. If the material is sized to the fineness that is really required the losses through the end of the screen will be excessive. Losses through the end of the screen can be reduced by placing obstruction segments in the screen, but these reduce the capacity. A monitor, by driving the gravel toward the head of the screen reduces the losses, but has the same disadvantage. At Larut, Mr. Newman proposes to roughly size the material as it leaves the screen and to pass it through a gravel pump into a separate box. If the mechanical difficulties can be overcome this would seem to be the most promising method of reducing these serious losses.

(*b5*) In practice the minimum velocity of water that will prevent the tables from banking is found by experiment. This velocity must be sufficiently high to keep the largest pebbles of waste rolling until they are discarded over the ends of the boxes. If the boxes are widened the thickness of the feed is decreased, and the velocity of water in the boxes may be lowered, with the result that particles of tin which were previously lost will then remain in the boxes. The other method of decreasing the velocity of water necessary without any alteration to the boxes is to reduce the size of the feed to the boxes. It is obvious that pebbles of say ½ in. diameter can be removed by a slower current of water than pebbles of a larger size of the same specific gravity. Finer sizing would also reduce the quantity of material passing on to the tables. The screen as at present designed is not able to cope with fine sizing, but a large proportion of the present losses from the tables of dredges which have been designed with a small table width could be reduced by attention to this point. It remains for the mechanical engineers to provide a screen in which this sizing can be efficiently carried out.

ORE TREATMENT AT THE FALCON MINE, RHODESIA.

At the November meeting of the Chemical, Metallurgical, and Mining Society of South Africa, R. H. Adam read a paper describing the method of treating the ore at the Falcon gold-copper mine in Rhodesia. The Falcon mine, situated at Umvuma, 160 miles from Bulawayo, has been producing for over two years. Its monthly output is about 200 tons of blister copper, 3,000 oz. of gold, and 6,000 oz. of silver. From 18,000 to 20,000 tons of ore are treated monthly, and of this quantity 14,000 to 15,000 tons consist of sulphide ore, containing 2½% copper in chalcopyrite, and 5 to 6 dwt. of gold. The chalcopyrite is associated with iron pyrite and pyrrhotite. In addition, about 5,000 tons of oxidized ore from an open-cut is treated, containing 0·3% copper and 4 dwt. gold per ton.

In the sulphide ore treatment, the ore is crushed to 2½ in. ring in three Hadfield jaw breakers. Four trommels with 1½ in. holes separate into fine and coarse ore, the products passing by belt conveyors to the mill bins. From the belt, picked ore, amounting to 9% of the total, is sorted for direct transport to the blast-furnaces. This contains 5½% copper and 9 dwt. of gold per ton. The mill contains 36 Nissen stamps, 26 of these being usually employed on sulphide ore, crushing 19 to 20 tons to ⅛ in. mesh in 24 hours. The stamp product passes direct over 12 Record vanners, the tailing from which passes to classifying cones for two 18 ft. by 5 ft. 6 in. tube-mills. The tube-mill product passes over 10 more Record vanners, the tailing from which, joined by the overflow of the tube-mills cones, runs over blanket tables. From the blanket tables the tailing is lifted by a 6 in. centrifugal pump to cone classifiers, the underflow from which is pumped back to the tube-mills, the overflow flowing to secondary cones preparatory to a partial de-watering for the flotation plant. The result of the water concentration is the production of 1,800 to 1,900 tons of concentrate per month, containing 5% copper and 19 to 20 dwt. gold per ton.

The underflow from the secondary classifiers goes to a sump, the overflow to three 30 by 10 ft. Dorr thickeners. Thickened sand and slime, with water in the proportion of 3½ to 1 of solids, is then pumped to a steady head box, the flotation oil being added to the pump to ensure thorough mixing. Before entering the first flotation cell a sample of the feed is automatically cut out. The flotation plant is of the Minerals Separation type, and consists of nine compartments, with agitators revolving at 250 r.p.m., producing a froth about 15 in. deep. This froth has a copper content ranging from 13 or 14% in the first compartment to 3% or 4% in the last, so that the froth from the last three compartments is returned to the original feed. From 10,000 to 11,000 tons of tailing is treated every month, the feed values being 1·8% copper and 2·3 dwt. per ton gold ; 2,000 tons of concentrate is recovered, containing 8 to 9% copper and 5 dwt. per ton gold by the Minerals Separation unit itself, the recovery being about 86% for the copper and 43% for the gold. The flotation concentrate gravitates to four 30 by 6 ft. collector vats, where the coarser material settles. The fine concentrate in suspension is run to a 25 by 8 ft. agitator, and thence to two filter-presses of the Dehne pattern. The coarser settled concentrate is shovelled out at bottom discharge doors, stacked on the surface to dry, and then trucked to the smelting plant. The tailing from the flotation plant is automatically sampled before passing to fine collectng vats, where slime is separated for transport to the slime dam, the sand being hauled to the dump.

Ten stamps are usually employed on oxidized ore, each crushing 25 tons per 24 hours to ⅛ in. mesh. The product is passed over four tables of the first vanner set, the tailing from these re-ground in a third 18 ft. tube-mill, and the product passed over three of the second vanner set and thence over blanket tables. The result is the recovery of 300 tons of concentrate monthly, containing 1·5% copper and 47 dwt. per ton of gold, which is sent to the sintering plant. About 250 tons of picked oxidized ore is used up every month in lining the converters.

The mill concentration plant recovers about 60% of the gold and 20% of the copper, while the flotation plant recovers 20% of the gold and 70% of the copper, a total extraction of 80% of the gold and 90% of the copper by concentration.

The mill concentrate from the collector vats is conveyed by trucks to the sintering plant, where twelve blast-roasting pots are in operation. These are hemispherical in shape, 8 ft. diameter and 4 ft. in height. They are situated on a platform 12 ft. above ground level for convenience in discharging and breaking up the sintered product. They have a capacity of 8 tons of charge each, and a charge requires about 8 hours' treatment. The charges are made up of mill concentrate 60% to 65%, granulated converter slag 15% to 20%, fine ironstone flux 10%, flue dust 10%. About 3,500 tons of sinter, containing 14 dwt. per ton gold and 3·2% copper is produced monthly. Very little of the flotation concentrate is sintered, as its fineness and sticky nature make it unsuitable for the process. The two blast-furnaces (one in use at a time) are each 120 in. long and 46 in. in width at the tuyere level, each furnace taking 300 tons charge in 24 hours, with an output of 36 tons of matte in that time. The charges consist of sinter, picked ore flotation concentrate, old converter linings, and customs ore, with additional flux in the form of limestone and blast-furnace returns. The fuel is a mixture of coke and coal. Experiments at the mine proved that up to 50% of coal could be used safely and with considerable resulting economy. The air-blast at about 20 oz. pressure is derived from two turbo blowers, with a capacity of 12,500 cu. ft. of free air per minute to 30 to 50 oz. per square inch. The matte, containing 32% to 35% copper, runs from the forehearths to 8 ton matte ladles, which convey it by electric crane to the converters. One converter is kept in operation, and one as a standby, while the shells of four others are being re-lined. They are of the upright type, of 15 tons copper capacity per 24 hours. They do four blows per day, consuming 36 tons matte and producing 12 tons copper. The latter is poured into steel ingot moulds, conveyed on carriages, producing ingots of 360 lb. weight, containing gold and silver to the value of 10 and 20 oz. per ton respectively. The smelting recovery is 96% for the gold and 90% for the copper. The blister is shipped to New York, to be refined, and the copper sold as electrolytic. Efficient equipment is provided for the recovery of flue dust from the sintering pots, blast-furnaces, and converters. The flues from these lead to the main flue, containing two settling-chambers, from which the flue extends about 900 ft. up the side of a hill to the brick stack, 150 ft. high by 8 ft. diameter. The settling-chambers are cleaned out every month, and the main flue once a year.

The author also discusses the flotation principle.

GEOLOGY OF THE WAR ZONE IN FRANCE.

Dr. Aubrey Strahan, head of the English Geological Survey, recently addressed the Vesey Club on "Geology at the Seat of War." We give herewith some extracts from the report of the lecture published in the *Geological Magazine* for February.

In connection with the operations on the western front a comparison of the geology with that of the South of England acquires a special interest. The severance of England from the Continent is, geologically speaking, a recent geographical incident. That the chalk escarpments of the North and South Downs are continued in the chalk escarpments which overlook Boulogne is obvious, and that the subdivisions of the Tertiary strata with which we are familiar in the London and Hampshire Basins are recognizable in the North of France and in Belgium is well known. Not only so, but the scenery characteristic of each formation is reproduced with fidelity. In one respect only the Continental deposits differ materially from those of our home counties. Over wide tracts there has been distributed, up hill and down dale, a fine yellow loam, the *limon* of Belgian geologists, which is doubtfully, if at all, recognizable in England. The thickness varies from 100 ft. in the valleys to a mere trace on the flanks of the higher hills, where it shades into hill-talus, but the material is generally spread as a mantle over the country regardless of elevation. This is the deposit with which our men are generally in contact in trenches and the smaller dug-outs, and which is in evidence on the clothes of those returning from the front. Much has been written on the origin of the *limon*. It has not the character of a stratified subaqueous deposit, and its fossils include no marine and but few freshwater shells. Land shells, however, are embedded in it, with the bones of various herbivorous and carnivorous mammals. Judged by all these characters, its uniformity of grain, its disregard of level, and its fossil contents, it has been attributed in the main to subaerial agencies. It is in fact a dust, distributed by the wind and retained wherever it settles on ground thickly clothed with vegetation. Like the loess, with which it has many characters in common, it appears to have been formed in countries which suffer from extreme alternations of dry and wet seasons. In dry weather the *limon* readily returns to a condition of dust; in wet weather it forms a mud unlimited in quantity and obstructiveness. But as a material in which trenches and dug-outs can be excavated with the minimum of labour it seems to have found some use. Under the *limon*, and for the most part visible only by means of wells or boreholes, lie the Tertiary and Cretaceous formations.

The southern margin of the Tertiary tract, which includes the London and the Belgian basins, runs near Basingstoke, Guildford, and Canterbury to the coast near Deal. It strikes the French coast south of Calais, and passes thence by Béthune, Mons, Namur, and Liège. As far as Béthune the margin lies within the lines of the Allies as at present situated, but thence southward it passes into ground occupied by the enemy. Along parts of the margin the strata, both the Tertiary beds and the Chalk below them, are tilted up at a high angle, as for example near Guildford, and in such a case the Chalk projects in a ridge, typically illustrated in the Hog's Back. But on the Continent the Chalk emerges at a gentle angle, and the passage from rolling Chalk downs to low undulating plains of Tertiary beds is gradual. Indeed, outlying patches of Tertiary beds, from a few acres to a few square miles in area, are scattered abundantly over the higher parts of the down. Geologically this tract is comparable to many parts of Hertfordshire, Buckinghamshire, Berkshire, Surrey, and Kent, and the close correspondence of the strata in detail gives a peculiar interest to a study of these parts of England at the present time.

In the London basin three groups are recognized in the lower Tertiaries, and in the Hampshire basin the same three groups with other higher Tertiary strata which have been removed from the London area by denudation. The lowest group, resting directly upon the Chalk, is known as the Reading Beds and Thanet Sands with pebble beds. The thickness of the group amounts to 100 ft. in places. At its base lies a layer of unworn chalk-flints coated with green silicate of iron, and interbedded in the sands are clays, often of a vivid red colour. These characters are reproduced in the *Landenien* of Belgium. The interbedded clay is known as the *Argile de Louvil*. The Reading Beds pass below the London Clay, and under suitable circumstances the water in them is held down under pressure by that impervious covering. In such cases, when a hole is bored through the clay, the water rises from the sand and overflows at the surface. This used to be the case years ago in parts of London, and well-borers sometimes found themselves in unexpected possession of an uncontrollable fountain which flooded their own and their neighbours' premises. On the Continent an artesian supply is still available in suitable conditions within the margin of the Tertiary basin. The water, however, is potable only near the margin; in the inner parts of the basin, far away from the outer edge, it is too heavily loaded with mineral matter to be usable.

The London Clay, which comes next above the Thanet Sand, has a thickness of 400–450 ft. It corresponds in character, thickness, and fossils to the *Argile de Flandres*, or the *Yprésien* of Belgian geologists, except that in Belgium it consists in the upper part of alternating bands of sand and clay. London Clay has its uses. Almost the whole of the system of tube-railways under London has been constructed in this watertight material. The earlier underground railways, the sewers, and other works were situated nearer the surface, and encountered large quantities of water in the superficial gravels; the tubes were protected by clay above and below, except in a few exceptional localities.

The Bagshot Sands come next above the London Clay. These attain a thickness of approximately 1,000 ft. in Hampshire, but in the London basin have been for the most part denuded away. Parts of them, however, still remain near Aldershot, Bagshot, and Ascot, and on the tops of Highgate and Hampstead hills. Wherever they exist they make their presence apparent by a characteristic scenery of heath or pine forest. In Belgium they are represented by the *Paniselien* and *Bruxellien* Sands, and there also they produce a type of country which is in strong contrast with that produced by the Yprésien Clay. The conspicuous hill on which Cassel stands is composed in the main of Paniselien Sand, though it includes some later formations on its summit. Eastward, as the Belgian Tertiary basin is approached, the Paniselien Sand comes on in greater force. It forms the bold range of hills which surround Ypres on its southern and eastern sides, and which includes the site of the famous Hill 60.

The Paniselien and Bruxellien Sands absorb a large proportion of the rain that falls upon them, and give out the water as springs at their base, where they rest upon impervious clays or along any interbedded clay-band. Bailleul draws, or used to draw, a part of its supply from a spring of this character in the side of Mount Noir, one of the hills south of Ypres. Ypres was supplied by similar springs at Dickebusch and Zillebeck, but the gathering-ground of the springs includes the scene of some of the most murderous fighting of the war and it may well be questioned whether water drawn from such an area can be usable. In other parts of Belgium a system, which is rarely seen in Britain, of driving tunnels under the larger tracts of such sands and collecting the water by branching galleries, has been adopted. Brussels is partly supplied in this way.

The Chalk of the southeast of England includes three subdivisions of more or less distinctive lithological characters. The Upper Chalk is a massive type of chalk set with nodules or rows of nodules of flint. This subdivision ranges to upwards of 600 ft. in thickness, and forms the upper and bolder part of the chalk escarpments. The Middle Chalk is a thick-bedded chalk generally devoid of flints, and the Lower Chalk includes much chalk marl. The Upper Chalk is the source of water of the majority of chalk wells. The Lower Chalk, on the other hand, though it may hold much water, yields it but slowly on account of its marly and almost impervious character. For this reason the Lower Chalk has been much discussed as a suitable stratum in which to drive a tunnel from Dover to Calais. In fact, the small part of the tunnel which has been driven is situated in this subdivision.

In the North of France these subdivisions of the Chalk present much the same characters as in the southeast of England, but there extends from near Calais toward Mons an underground bar, which clearly existed in the Cretaceous sea as a ridge or at any rate an obstruction to the free circulation of currents. The Upper Chalk, though it crosses the bar, changes its character. The whole formation assumes a marly character under Flanders, and loses its value as a reliable source of good water. Herein lies the difficulty of finding water supplies in Eastern and Western Flanders. The Landenien water is often not potable, and the Chalk yields none. The Palæozoic rocks beneath yield salt water, if any, and the uplands of Paniselien Sand are too limited in area to give a sufficient supply by gallery. Under these circumstances recourse has been had to rain and canal water, rendered harmless, as believed, by chemical treatment and filtration. So keenly was the lack of good water felt that a project was on foot before the war to supply the towns of Low Belgium from a source in the Ardennes. The supply had been carried to Brussels, and its further distribution was in progress when the war broke out.

Chalk forms one of the most suitable rocks for dug-outs, provided that the excavations are not carried below the level of the underground water. It is not difficult to excavate, and yet firm enough to stand fairly well. The extensive and elaborate system of underground dwellings recently captured by our troops have been excavated in the Chalk.

Sand and Ash for Stope-Filling.—The *Monthly Journal* of the Chemical, Metallurgical, & Mining Society of South Africa for November contains a paper written by Christopher Toombs describing the use of a mixture of ash and sand for stope-filling employed at the Angelo section of the East Rand Proprietary Mines. One of the oldest of the sand dumps, on the New Comet section, was being used for filling; but it was found that the acid content, both free and as iron sulphate, was very high, so much so that the amount of lime required to neutralize the water carrying the sand underground was far too great for economy. A number of tests showed that the total acidity of the water carrying the sand averaged 1·1%, which required the addition of 20 lb. of air-slaked lime containing 60% CaO per ton of sand. On a basis of 1,000 tons of sand per day, 10 tons of lime costing £25 would be required to give a neutral overflow and drainage water. To secure a cheaper source of lime, attention was turned to the ash from the power-plant. Most of the Transvaal coals give an ash containing lime. When the ash comes from the furnaces the lime exists as calcium oxide, the amount being from 25 to 40 lb. per ton of ash. After the ash has been exposed to the weather on the dump for a short time, the calcium oxide is all changed to carbonate. Mr. Toombs conducted many experiments to obtain a suitable mixture of dump-sand and ash. In the course of these experiments he found that the calcium carbonate in the dump-ash neutralized the free sulphuric acid, but did not attack the ferrous and ferric sulphates; and as it was not convenient to use ash fresh from the furnaces, it became necessary to use lime as well. If lime is added at the time the ash and sand are mixed, it is consumed largely in neutralizing the free acid and thus is lost for neutralizing the sulphates. The plan finally evolved was to add the lime at as late a period as possible, so as to give opportunity for reaction between the calcium carbonate of the ash and the free acid, before the lime is added. An idea of the proportions of sand, ash, and lime employed is given by the October figures: dump-sand 22,000 tons, dump-ash 2,200 tons, lime 13 tons. The amount of lime used is apparently about one quarter of what it would otherwise have been. The mixture of sand and ash makes an excellent filling, and sets harder than sand alone. Moreover the mixture drains quicker than the sand

Flotation of Arsenical Gold Ore.—In the *Monthly Journal* of the Chemical, Metallurgical, & Mining Society of South Africa for November, F. Wartenweiler describes experimental work on flotation with arsenical gold ore in the sulphide zone at one of the Barberton mines. This ore had responded badly to other methods of treatment. Sliming and direct cyaniding gave a maximum recovery of 45%. Roasting and cyaniding gave 82%; this low recovery combined with high costs made the process prohibitive. Removal of the pyrite and arsenopyrite by table concentration and cyaniding the tailing gave 70% recovery. Minerals Separation tests were then made.

It was found that good results were obtained with a water slightly alkaline equivalent to 0·005% CaO, with a pulp containing 5 of water to 1 of solids, the ore ground to 90 mesh, and using wood creosote and paraffin. At this mesh some of the coarser sulphide and arsenopyrite was not floated, and it became therefore advisable to supplement flotation by tabling the sandy tailing. Otherwise greater efficiency in flotation could be secured by crushing finer, but at an enhanced cost. It was proved on an experimental laboratory scale that the best plan is to roast and cyanide the concentrate, send the tailing to a classifier to be separated into sand and slime, pass the sand over tables to extract coarse sulphide and arsenopyrite (which is delivered to the other concentrate) and cyanide the sand and slime. By this plan a recovery of 84% was obtained, and as the roasting is applied only to concentrate and not to the ore in bulk, the cost of treatment is within the required limit.

Tungsten Production in England.—In several recent issues, *The Mining Journal* has given particulars of companies engaged in producing metallic tungsten and ferro-tungsten in this country. In the issue of November 25 a general review of the subject was given, together with an account of the process and works of the High-Speed Steel Alloys Company at Widnes. On December 2 the works and the process of the Thermo-Electric Ore Reduction Corporation, at Luton, were described. These were followed on January 13 with an account of the operations at the works of Thermit, Limited, in Commercial Road, London, E. In the issue of January 20, the judgment of Mr. Justice Astbury in the case of the British Thomson-Houston Co. v. Duram was given; this case involved a dispute as to the priority of patents for making tungsten filaments, and a great deal of valuable information was brought out and is recorded in the judgment.

At the High-Speed Steel Alloys plant the concentrate is heated in a reverberatory with carbonate of soda, the resulting tungstate of soda extracted by leaching, the tungstate precipitated as oxide by hydrochloric acid, and the oxide smelted with anthracite for the production of tungsten powder. The Thermo-Electric company produces tungsten powder by the same process, and also ferro-tungtsen and other ferro-alloys in the electric furnace. Thermit, Limited, produces ferro-alloys by the aid of the heat of the burning of metallic aluminium. Neither of the last two companies gives any technical information relating to its process. A number of other companies are working on tungsten production, among which may be mentioned The British Thermit Company, of Garston, near Liverpool, The Tyneside Alloys Company, the Continuous Reaction Process Company, and the British Metal Reducers Company, but no details regarding these have been published.

Metallurgy of Tungsten.—W. E. Koerner presented a paper at the September meeting of the American Electro-Chemical Society on the electrolytic behaviour of tungsten. This paper is reprinted in *Metallurgical and Chemical Engineering* for January 1. The author reviews the various attempts and proposals for extracting tungsten from its ores by solution and electro-deposition, but comes to the conclusion that the investigators usually obtained not pure metal but a sub-oxide. He then describes in detail a great number of experiments undertaken to elucidate the electrolytic behaviour of tungsten. This work was done in the Edison Lamp Works, New Jersey. The author promises a further communication. The bibliography attached to the paper is useful.

Tin Assay.—At the meeting of the Institution of Mining and Metallurgy held on February 15, H. W. Hutchin read a paper detailing research work undertaken with the object of detecting possible errors in the various wet methods of tin assay. Reference is made to this paper in our editorial columns.

RECENT PATENTS

8,606 and 9,485 of 1915. W. WEBER, Hayingen, Germany. Explosive cartridges for blasting purposes containing combustible metallic powder, liquid air, and an organic combustible substance.

16,602 of 1915. F. COCHLOVIS, Buchschag-Hessen, Germany. Rotary electric furnace for zinc-smelting.

7,254 of 1916 (103,415). C. H. THOMPSON and E. K. SCOTT, Birmingham. Method of producing tin oxide from metallic tin in an electric furnace.

1,004 of 1916 (100,034). E. STOPPANI and V. VOLPATO, Milan. Heating natural phosphate with carbonate of soda for the purpose of producing a soluble phosphatic manure.

788 of 1916 (100,259). Metallbank and Metallurgische Gesellschaft, Frankfort, Germany. Improvements in patent 6,917 of 1913, relating to methods of charging roasting furnaces.

10,151-2 of 1916 (101,025 and 101,086). F. C. FRARY, Niagara Falls, and S. W. TEMPLE, St. Paul, U.S.A. A lead alloy containing 2% calcium and a small proportion of copper, to be used as a substitute for antimonial lead in the manufacture of bullets and type-metal.

16,867-8 of 1915. Thermic Plating Process Co., New York. Method of plating iron with copper.

3,185 of 1916 (100,778). Deutsche Gold und Silber Scheide Anstalt, Frankfort, Germany. Manufacture of Sodium Perborate.

3,271 of 1916 (103,205). A. S. MOSES, New York. An automatic lead-smelting furnace operating on the principle of the Scotch hearth.

5,781 of 1916 (103,232). R. HALKETT, Glasgow. An improved gas-fired crucible furnace.

NEW BOOKS

The Analysis of Copper. By George L. Heath. Cloth, octavo, 220 pages, illustrated; price 12s. 6d. New York: McGraw-Hill Book Co.; London: Hill Publishing Co.

The author is chief chemist at the Calumet & Hecla Company's smelting works. It is not too much to assert that this volume at once becomes indispensable to the libraries both of the copper producer and the analyst, for it constitutes, as its author is justified in claiming, the first connected account of the principal approved analytical and other methods employed by the largest copper smelters, refineries, and custom-sampling works in America and Europe. The exceptional experience of the author is reinforced by that of the foremost copper technicists. The chief chemists and managers of the Anaconda, Perth Amboy, Raritan, Canadian Copper Co., Douglas, and Mansfeld, smelters and refiners—to mention but a few—have contributed to the concensus of methods here welded into a coherent and authoritative treatise of unique value.

Space does not permit of a review which would be adequate to the merits of Mr. Heath's book. Suffice it to say that the subject matter is arranged to follow closely the course of the reduction and handling of the metal, from the sampling and crushing of its ores, through its intermediate furnace and refinery products and by-products, to the chemical, physical, and micrographic tests for the finished metal, and the analysis of its chief alloys.

Many new and special methods are given, and valuable modifications in several hitherto accepted as standard are discussed in detail. Features of outstanding value are the pages devoted to the consideration of sampling and crushing, with its literature, metallography of copper and brass, and "resistivity" determination. In a word this is a volume that the copper-man cannot afford to be without.

H. L. S.

A Handbook of Briquetting. Vol. I. By G. Franke, translated by F. C. A. H. Lantsberry. Cloth, octavo, 640 pages, with 234 illustrations; price 30s. net. London: Charles Griffin & Co. Ltd.

The author is professor of mining at the Bergakademie, Bèrlin. This first of the two volumes deals with the briquetting of coal and other fuels. The second volume, to follow later, will treat the briquetting of ores and various metallurgical products. The subject of utilizing small coal has been more pressing in Germany than in this country and America, for though the fuel resources are large, the proportion of high-class coal is small. Thus the saving of dust and fines has been carefully studied. Now that we have a Fuel Economy Commission in this country, this important item of economic detail will receive attention. In fact this translation appears at an opportune moment, and not a few people will thank the house of Griffin for their timely presentation of the volume. The book, however, deals solely with German practice, and it must be remembered that much has been done in the same line in England and France.

The book opens with a chapter on the general benefits arising from the use of coal briquettes, and a chapter follows on binding materials. Other chapters deal with crushing, kneading, mixing, pressing, and drying. Descriptions are then given of typical briquetting factories. Another chapter analyses costs. A separate section of the book is devoted to the preparation of lignite and brown-coal briquettes. Here the problem is slightly different, owing to the large moisture constituent. The various applications of briquettes for heating, steam raising, and for producer-gas manufacture are described at length. A chapter is devoted to the dangers in briquette manufacture, chiefly arising from the formation of dust. We miss, however, any reference to the skin diseases that arise from the use of pitch in briquetting.

Australia. By J. W. Gregory, Professor of Geology in the University of Glasgow. Cloth, pocket size, 160 pages, illustrated; price 1s. 3d. net. Cambridge: The University Press.

We confess to a liking for all Professor Gregory's writings. He has an unrivalled ability for compressing the largest number of ideas and facts into the smallest number of words, and at the same time presenting them pleasantly and clearly and without any tendency to stodginess. His little book on Australia bears this mark of the author's genius. It is one of the Cambridge Manuals, a series that has won a high reputation among intelligent students. The first chapter gives a succinct account of the discovery and exploration of Australia, and then comes an account of the physical geography of the continent. Other chapters deal with the flora and fauna, the aboriginal inhabitants, and the mineral, vegetable, and animal products. Land tenure, the system of government, the finances, and industrial and social legislation are all explained clearly. We quote herewith the author's review of general conditions, a statement which is sure to be appreciated by our readers.

"Australia is sometimes represented as a monotonous country, a fringe of inhabitable land round a useless desert; it has, it is said, a stagnant population because its gold mines no longer attract immigrants; its soil is easily exhausted; it is burdened with a debt of over £60 per head; it is tending to inevitable bankruptcy under the incompetent rule of a caucus of envious demagogues.

"Facts present a totally different picture. Australia is a land of exceptional variety and beauty. Though the rainfall in the interior is low, yet owing to its seasonal distribution and the nature of the soil and climate, it can be used to the best advantage. The population is still quite inadequate, for Australia could no doubt maintain in comfort 100,000,000 people; yet considering its remote position Australia has done very well to have raised its population from 405,000 to 4,750,000 in about sixty years. Though the gold yield is diminishing, Australia has vast reserves of other minerals, including coal, iron ores, oil-shale, and china-clay, and the decrease from the gold mines is partly due to the fact that gold is the one product whose price cannot be raised by its producers. Gold mining is the industry which is most seriously affected by a general rise in prices, as it cannot recompense itself for increased working costs by charging higher for its produce.

"The productivity of Australia per head of population is unequalled. The resources of the country are immense. The debt though large is covered by the railways, and other public works. And Australia, instead of travelling down an easy road to ruin, is pursuing a strenuous, progressive policy, which is dictated by the highest ideals of citizenship.

"The economic success of Australia would have been impossible had not the Australians faced their new problems with fearless confidence, and solved them by patient experiment, unusual originality, and unflinching thoroughness in work. These qualities have been shown by the pioneers in pastoral settlement, by its skilled sheep breeders, by the mining prospectors who discovered the Australian goldfields, by the mining engineers who devised new methods of working the ores, and by the politicians who, animated by the same spirit, are resolute that the degrading poverty of the European and American slums shall find no home in Australia.

"The characteristic which always seems to me the chief distinction of Australian politics is its dominant idealism. The Australian differs perhaps most strikingly from the American and Canadian by being more idealistic and less romantic. The average American seems to me essentially a romanticist, for he is interested in the unusual because it is unusual. The Australian on the contrary is an idealist, for he does not care much for novelty unless it offers some prospect of improving present conditions. He shows in an especially strong degree that combination of the imaginative and the practical, which is the most marked characteristic of the British race.

"The Australian is therefore not to be turned from his path by showing him that his measures for the benefit of his artizan class impoverish the country by delaying its development and enrichment. For much of the social legislation of Australia is based on the deliberate rejection of the view that financial success is any real test of national prosperity. The well known award by Mr. Justice Higgins on the Broken Hill strike clearly expresses that principle. The miners demanded a wage which according to the employers the mine could not pay. The Judge estimated the lowest wage on which a man could be expected to live in reasonable comfort and maintain his health, with the prices and conditions ruling in that isolated expensive mining field. Having determined what he considered a living wage he declared that if the mine could not pay as much, it must close down until a rise in the price of metals or fall in local costs enabled the mine to give a living wage. It is fully recognized that the industrial and social legislation of Australia is to some extent raising the cost of production, is preventing the establishment of certain industries, and is restricting the growth of others. Australia adopted her present industrial policy fully prepared to pay the cost. The question is whether the financial handicap that has been accepted will seriously hamper the development of the continent. Statistics show that Australia is making magnificent progress, and the fact that the price of Australian securities rose in Europe during the first Labour administration indicated that British capitalists had no real fear that Labour rule was any real menace to Australian progress.

"The determination of Australia to secure the well-being of its working classes may reduce its wealth-producing power; but that does not prove that the policy is unsound or even extravagant. It only shows that in contrast with the prevalent materialism of the time, Australia recognizes that it is the duty of a State to safeguard its citizens against intellectual as well as against bodily foes. Australia is striving to secure conditions which will foster the growth of a higher average standard of character than has been possible in the uneven and conflicting growths of the older nations. The prospects of success are hopeful."

The Mining Manual and Mining Year-Book for 1917. By Walter R. Skinner. Cloth, octavo, 970 pages; price 15s. net. London: W. R. Skinner, and *The Financial Times*.

For thirty years Skinner's Mining Manual has been one of the indispensables of the City of London. It gives us the particulars of all the mining companies registered or otherwise known in England. Its accuracy is worthy of note. We have a complete set from the beginning, and when we desire relaxation in the way of light and instructive reading, a perusal of one of the early volumes is more entertaining than a revue.

Geology of the Country South of Kalgoorlie. By C. Sidney Honman. This is Bulletin No. 66 of the West Australian Geological Survey. The region covered includes the mining centres of Golden Ridge, Boorara, and Feysville, and a tract of country to the west of Lake Lefroy.

Bibliography of Australasian Mineralogy. By C. Anderson. This volume is No. 22 of Mineral Resources, published by the New South Wales Geological Survey. The author is mineralogist to the Australian Museum. The references to occurrences of minerals are classified under the authors' names, then comes an index to these under each individual mineral, and then an index to the minerals under place names,

Geography and Geology of West Central Sinai. By Dr. John Ball. This monograph is published by the Geological Survey of Egypt. This region is of interest owing to the occurrence of oil and of iron and manganese deposits

Royal Cornwall Polytechnic Society. The 83rd Annual Report, just issued, contains a report of the summer meeting held in August 1915 at Falmouth. The proceedings included the address of the president Mr. Henry Jenner; Mr. W. H. Trewartha-James's explanation of J. J. Beringer's microscopical work on tin ores; and papers by J. H. Collins on Tin and Tungsten in the West of England, and by J. M. Coon on Mechanical Appliances in China Clay Works.

TECHNICAL PAPERS

BRITISH

Colliery Guardian.—*February 9:* Coaling Depots at South American Ports, F. J. Warden-Stevens; Nationality and Originality in Mining. *February 23:* Coaling Stations in the Atlantic Islands, F. J. Warden-Stevens.

The Engineer. — *February 16*: What Industry owes to Science, leather, rubber, mortar and cement.

Engineering.—*February 16*: The Peters High-Purchase Grab; A Portable Trench Pump Set mounted on an Austin motor lorry; Telpher Installation at the Dalmarnock Gas Works. *February 23*: The Carbo-Teredo Process for Preserving Timbers from Borers, J. E. Cunningham.

Geological Magazine.—*February:* Rhythmic Deposition of Flint, G. A. J. Cole; Geology at the Seat of War, Aubrey Strahan.

Institution of Mining and Metallurgy.—*February 15:* Wet Assay of Tin Concentrate, H. W. Hutchin; Mining the Swaziland Alluvial Tin Deposits, J. Jervis Garrard.

Institution of Petroleum Technologists.—*February 20:* Liquid Fuel and its Combustion, J. S. S. Brame.

Iron and Coal Trades Review.—*February 9:* Briquetting Plant at Clifton Colliery, Nottingham; The Wheddon Overwind and Overspeed Preventer; Resuscitation from Mine Gases, F. P. Mills, paper read before the North of England Branch of the National Association of Colliery Managers; Ferro-Concrete Props at Arley Colliery, Warwick; Ashford's Strainer for Tube Wells; Principles of Industrial Administration, G. E. Toogood [continued February 23]; Deterioration of Open-Hearth Refractory Materials, H. B. Cronshaw, from a Carnegie Research Memoir. *February 16:* Bare-Wire Signalling Systems, a discussion before the North Staffordshire Branch of the National Association of Colliery Managers; Head-Wrightson's Self-Adjusting Pit Props; Endless Rope Haulage at the Oakbank Oil Co's. Works, Scotland. *February 23:* Iron and Steel Syndicates in Russia; The Moll Burner for burning gas for steam-raising.

The Mining Journal.—*February 10:* Russian Platinum Position, T. H. Preston. *February 17*: Present Position of the Aluminium Industry; Starting a Magnetic Separator for Wolfram Ores at Tavoy, Burma.

Philosophical Magazine.—*December:* Compression of the Earth's Crust in Cooling, Harold Jeffreys.

Royal Institution of Great Britain.—*February 27:* The Strength and Structure of Metals, W. E. Dalby.

Society of Chemical Industry Journal.—*January 31:* Production of Nitrate of Soda in Chile, Past, Present, and Future, I. B. Hobsbaum and J. L. Grigioni; Portable Plant for the Distillation of Wood Waste, S. H. Collins. *February 15:* Utilization of Waste Heat from Coke-Making, Henry Peile; Notes on the Working of the Bettington Boiler heated by Powdered Coal, C. A. King.

COLONIAL

Canadian Mining Institute Bulletin.—*February:* Canada's Future—Some Suggestions, David H. Browne; Coal-Mining Conditions and Industry in Alberta, J. T. Stirling; The Zinc Situation in Canada, Alfred Stansfield; The Atlin Magnesite Deposits, N. Thompson; Notes on Local Treatment of West Kootenay Silver Ores, F. A. Thomson.

Canadian Mining Journal.—*January 15*: Coal Trade of Nova Scotia during 1916, F. W. Gray; Coal in British Columbia during 1916, E. Jacobs; Some Historic Rock-Drills, H.B. Willmott.

Chemical, Metallurgical, & Mining Society of South Africa Journal.—*December:* Removal of Rust from Iron Plates, F. W. Watson.

Queensland Government Mining Journal—*December:* The State Battery at Bamford, on the Chillage Railway; Queensland's Resources of Diatomite, B. Dunstan.

South African Institution of Engineers Journal.—*January:* Boiler Practice at the Rand Power Companies' Electrical Plant, T. G. Otley and V. Pickles.

West Australian Chamber of Mines Journal.—*November*: Recent Improvements in Vacuum Filtration Plants, T. B. Stevens.

Mining and Engineering Review, Melbourne.—*January:* The Chillagoe Tangle; Evolution of the Cyanide Process in New Zealand, giving particulars of the installation at the Crown Mines in 1889, J. McCombie; Slate Deposits near Goulbourn, New South Wales; Revivifying the Bendigo Goldfield; Conditions in the Collie Coalfield, West Australia, abstract of official report.

Monthly Journal of the Chamber of Mines of West Australia. — *November:* Recent Improvements in Vacuum Filtration Plants, Thomas B. Stevens.

FOREIGN

American Institute of Mining Engineers Bulletin. —*February:* Magnetic Concentration of Low-grade Iron Ores, S. Norton and S. Le Fevre; Investigation in Rock Crushing at McGill University, J. W. Bell, comparing Kick's and Rittinger's laws; Evidence of the Oklahoma Oilfields on the Anticlinal Theory, Dorsey Hager; Significance of Manganese in American Steel Metallurgy, F. H. Willcox; Comparison of Methods of Cleaning Blast-Furnace Gases, L. Bradley, H. D. Egbert, and W. W. Strong; Portable Miners' Lamps, E. M. Chance; Notes on Flotation 1916, J. M. Callow.

Engineering and Mining Journal.—*January 20:* The Rochester Cyanide Plant, Nevada, A. C. Daman; Filing Survey Data at Mines, R. S. Schultz [continued January 27]. The Denver Rock-Drill Sharpener. *January 17:* The Coro-Coro Copper District of Bolivia, J. T. Singewald and B. L. Miller; Open-cut Steam-Shovel Costs, J. M. Anderson; Flotation of Stibnite Ores, J. Daniels and C. R. Corey; An Automatic Sampler, A. C. Daman; New Method of Zinc Precipitation, H. R Conklin. *February 3:* Operating Conditions in the San Juan Country, Colorado, L. H. Goodwin; Flotation at the Magma Plant, at Superior, Arizona, J. M. Callow; Symposium on the High Cost of Mining, Milling, and Smelting; Origin of the Sudbury Nickel Ores, C. F. Tolman and A. F. Rogers; The Chilean Nitrate Industry, A. W. Allen. *February 10:* Twenty One Years Mining at the Yellow Aster Gold Mine, California, L. H. Eddy; Mining Conditions at Potosi, Bolivia, B. L. Miller and J. T. Singewald; Zinc-Box Work, H. T. Durant; Operating a Steel-Sharpening Shop, J. E. O'Rourke; Method of Assaying Tin Ores, G. M. Henderson; Design of a 1,000 ft. Smelter-Stack, N. L. Stewart; Hidden Creek Mine and Smelter, Anyox, D. G. Campbell.

Metallurgical and Chemical Engineering. — *February 1:* Calculation of Lead Blast-Furnace Charges, II., Boyd Dudley; Metallurgy of Cadmium, F. Juretzka, translated by O. C. Ralston; Volatility of Gold at High Temperatures in Air and other Gases, W. Mostovich and W. Pletneff; Fulton's Electric Zinc Smelting Process; Electrolysis of Gallium Solutions, H. S. Uhler and P. E. Browning.

Mining and Scientific Press.—*January 13*: Dredging for Gold on the Seward Peninsula, Alaska, during 1916, C. C. Brayton; Design and Operation of Motor Trucks, W. H. Clapp. *January 20*: The Nickel Plate Mine, at Hedley, British Columbia, containing Arsenical Gold Ore in Limestone, T. A. Rickard; The Chemistry of Manganese, M. L. Hartmann; Conditions in Mexico. *January 27*: Platinum in California, E. P. Brooks; Interview with J. H. Mackenzie, T. A. Rickard; Geological Occurrence of Manganese, J. J. Runner. *February 3*: The Bunker Hill Lead Smelter, J. Labarthe; Zinc Oxide from Lead Slag, H. B. Pulsifer and G. Perlstein; Abstract of Brief in the Appeal by the Miami Copper Co. against the decision of the first court in the case brought by the Minerals Separation.

COMPANY REPORTS

Arizona Copper.—This company has its headquarters in Edinburgh, and was formed in 1884 to work copper mines at Clifton, Arizona. Four years ago the smelting plant was rebuilt, and operations were reorganized, so as to treat more economically the great reserves of lower-grade ore. The report for the year ended September 30 last shows that the remodelling and enlargement of the concentrators and the erection of flotation plant has been completed. During this period the mine and smelter were idle for nearly five months on account of prolonged labour troubles. Ore was drawn from a dozen workings, totalling 905,486 tons, of which 40,446 tons was sent to the smelters and 865,040 tons to the concentrators. The largest individual producing mines were the Humboldt with 484,172 tons, the Coronado with 125,774 tons, and the Clay with 124,763 tons. The output of copper was 17,050 short tons (equal to 15,232 long tons), of which 9,039 tons was sold as bessemer and 8,011 tons as electrolytic. The income from the sale of copper was £1,855,941, and the gross profit £988,225. Out of this profit, £81,409 was paid as debenture interest, £156,227 was allocated to the redemption of debentures, £120,000 was carried to reserve account for capital outlay, and £24,531 was paid as preference dividends. The ordinary shareholders received £303,979 free of tax, being at the rate of 80%. Since the close of the company's financial year, £145,000 of debentures have been redeemed.

Mexico Mines of El Oro.—This company was formed in 1904 by the Exploration Company to acquire a mine at El Oro, Mexico, from the Mexican Gold & Silver Recovery Co., the latter company being the organization formed in earlier years to work the MacArthur-Forrest cyanide patents in Mexico. The mine is situated on the same system of lodes as the El Oro and Esperanza mines. In our issue of May 1915 we published an article by the manager, F. L. Allan, describing the mine and the nature of the deposits. In 1910 the control passed to the French and Pearson interests, and though the company is registered in England, the head office is now in Paris. The report for the year ended June 30 last shows that during this period the mill was idle owing to the political disturbance in Mexico. As already recorded in our columns, operations were recommenced at the end of August 1916. From then until the end of 1916, 31,000 tons of ore was milled. The reserve of ore stands at the same figure as the year before, 505,300 tons averaging 10·4 dwt. gold and 6·4 oz. silver per ton. The year under review commenced with a balance in hand of £91,126, and ended with a balance of £59,072. The results since the resumption of operations in August last have been so satisfactory that the directors have decided to pay a dividend at the rate of 35%, absorbing £63,000. Some time ago an agreement was made with the Oro Nolan for the purchase of property on the dip belonging to the latter company. Permission has been received from the English and French Governments for the completion of this purchase, by the issue of 30,000 shares, of the par value of £1, but of £4 market value.

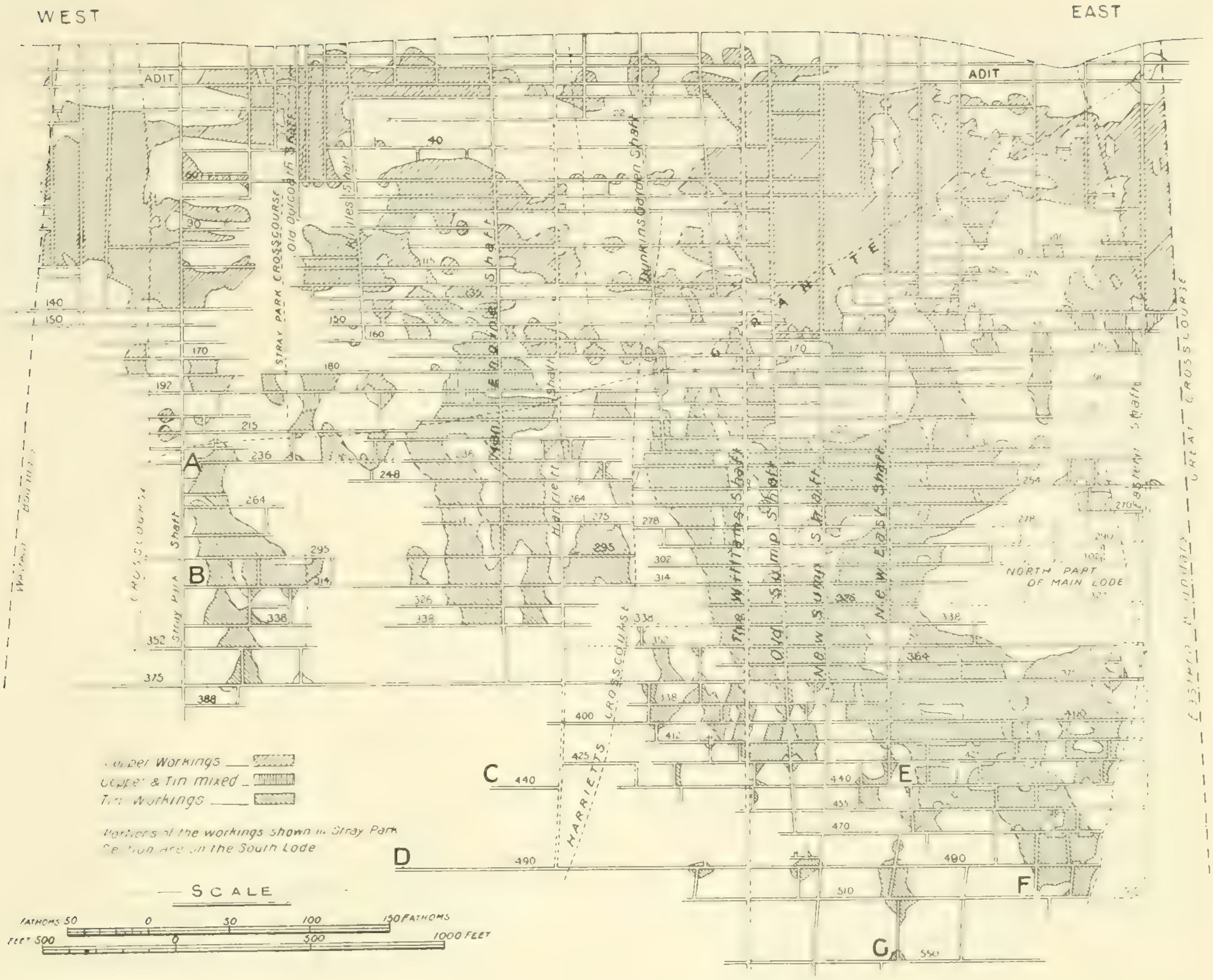
Tongkah Harbour Tin Dredging.—This company was formed ten years ago, under Tasmanian laws and control, for the purpose of dredging tin gravel on the shore at Puket, Tongkah island, off the coast of the Western Siamese States. On several occasions we have given the earlier history of the company. The report now issued covers the year ended September 30 last. During this period the five dredges treated 3,363,750 cubic yards for a yield of 1,076 tons of tin concentrate. The amount treated compares with 2,968,600 yards the year before, and 2,199,408 yards two years previously. The yield per yard was 0·717 lb. as compared with 0·953 lb. and 1·147 lb. The receipts accruing from the sale of concentrate, after deducting royalty, were £114,993, equal to 8·2d. per yard. Dredging costs were £56,938, or 4·026d. per yard, and administration and other costs £8,049, or 0·574d. per yard. The net profit was £40,808, or 3·568d. per yard. During the year four dividends of 10% each were paid, absorbing £60,000, part of which was paid out of the balance, £71,507, brought forward from the previous year. Eliot T. Lewis, the manager, gives a detailed report of the results of boring, and he shows that the ground so proved is sufficient for three years work of the dredges. The outer parts of the harbour are now to be bored.

Wolhuter Gold Mines.—This company was formed in 1887 to acquire claims on the outcrop in the Central Rand, to the east of the Meyer & Charlton. During the earlier years the results obtained were far from satisfactory. Milling started in 1888, and a new plant was erected in 1895. This mill was destroyed by fire in 1905, and was replaced in 1906. Dividends were paid in 1894, 1897, 1898, and from 1909 to date, the average yearly distribution being about 12½%. The report for the year ended October 31 last shows that the amount of ore raised was 472,733 tons, and after the rejection of 10% waste, 424,500 tons was sent to the stamps. The yield of gold by amalgamation was £383,906 and by cyanide £147,476, being a total of £531,382, or 25s. 1d. per ton milled. The working cost was £370,159, or 17s. 6d. per ton, leaving a profit of £161,223, or 7s. 7d. per ton. Taxes, etc., absorbed £35,540, and £129,000 was distributed among shareholders, being at the rate of 15%. During the year the ore reserve has been fully maintained by development, and stands at 1,302, 160 tons averaging 6 dwt. per ton. The control is with Neumanns, David Wilkinson is consulting engineer, and E. E. Hardach manager.

Falcon Mines.—This company was formed in 1910 by the Gold Fields Rhodesian Development Co. to work a gold-copper deposit 60 miles east of Gwelo, Rhodesia. The ore, both oxidized and sulphide, is smelted in a blast-furnace, the metallurgical plant containing also flotation machines, sinterers, and converters. Smelting commenced in June 1914. The report now issued covers the year ended June 30 last. During this period, 57,955 tons of oxidized ore and 160,837 tons of sulphide ore was treated for a yield of 3,477 tons of blister copper, containing 3,411 tons of copper, 38,569 oz. of gold, and 73,862 oz. of silver. The blister copper sold for £530,826, equal to 48s. 6d. per ton of ore treated. The working cost was £335,138, or 30s. 7d. per ton, leaving a working profit of £195,688. Out of this profit, £30,000 was provided for income tax, £12,582 was paid as debenture interest, £13,372 was paid as interest on the loan, £30,000 was allocated to the debenture-redemption account, and £73,750 was written off underwriting-commission account. No dividend was paid. The issued capital is £400,000, there are £217,341 debentures, and £119,975 loan. Development during the year maintained the reserve, which stood on June 30 at 119,838 tons of oxidized ore and 742,228 tons of sulphide ore. The oxidized ore is now being exhausted, and, owing to difficulties in mining, it is not being kept as free from gangue as is desirable. The orebody is developing satisfactorily in depth. H. A. Piper gives details of the work done. The main shaft has been sunk to the 9th level, and the ground between this level and the 7th is being opened. The shaft is to be continued to an 11th level. On the 9th level the lode averages 50 ft. wide, with a content of 6 dwt. gold and 2⅓% copper.

Dolcoath Mine.—The report of the company owning this old Cornish tin mine, covering the half-year ended December 31 last, shows that 37,963 tons of ore was raised, and that the yield of tin concentrate was 500 tons. The amount of ore compared with 57,254 tons during the half-year preceding the war. The yield of concentrate per ton was 29·5 lb., which is not much less than the average of the last three years. The output of concentrate was the lowest during the life of the present company, and compares with 1,015 tons from 28,717 tons of ore during the first half year ended December 31, 1895, and 1,000 tons from 45,880 tons during the first half of 1909. The receipts from the sale of concentrate were £49,853, the average price per ton received for black tin £99. 12s. 6d., and the receipts per ton of ore 26s. 3d. Other income brought the total revenue to £50,429. The working cost was £50,016, and £3,323 was paid as lord's royalty, while £1,257 was written off for depreciation of plant aud buildings. The report is accompanied by a longitudinal section of the workings on the main lode, and by a statement of output, income, expenditure, and dividends since the start of the present company in 1895.

R. Arthur Thomas, the manager, writes of the recent development. References are to the longitudinal section of the mine given herewith. This we reproduce herewith. The 440 fm. level (see E) is now 49 fm. east of New East shaft, and for the last 15 fm. the average value has been 50 lb. of black tin per ton. Of late, the lode in the end has decreased in value, which has brought down the average. This end will shortly hole to some of the old workings, after which a rise will be put up above this level, and simultaneously other exploratory work will be undertaken as soon as circumstances, with the limited number of men available, will permit. The exploratory work at the 550 fm. (see G) is still producing ore averaging about 30 lb. of black tin per ton. Some exploratory work recently undertaken at the 510 fm. (see F) east of New East shaft has discovered some tin ground the extent of which cannot yet be ascertained, and sufficient work has not been done here or at the E and G to correlate them, The 338 fm. level has been driven 24 fm. east of New Sump shaft, and a connection will shortly be made to the old workings, from which it is hoped to secure large quantities of moderately productive ore. The 254 fm. level has been driven from New Sump shaft in the foot-wall granite, and has been holed by a cross-cut south to New East shaft. It is hoped to obtain some low-grade tin ground here, which will be



LONGITUDINAL SECTION OF DOLCOATH MINE.

drawn through the New Sump shaft. New Sump section has contributed 34·7% of the total tinstuff drawn, and 32·3% of the black tin sold. It was anticipated that some tin ground would be found in the region of the subsidiary shaft sunk north of New Sump shaft some time ago, but unforeseen circumstances arose which made it impracticable; the difficulties, are, it is hoped, overcome, and it is expected that this ground will now be worked. Old Sump shaft has contributed 5·2% of the total ore drawn and 4·9% of the total black tin sold. The total ore drawn from the eastern section of mine was 43·6% of the total output, and the black tin produced was 45% of the total. Owing to the shortage of miners, it is still impossible to carry out any development work in this part of the mine.

Wheal Harriet has contributed 5·8% of the total ore drawn, and 8·0% of the black tin sold. The 490 fm. level (see D) is driven 98 fm. west of Wheal Harriet shaft on the main lode. Two cross-cuts have been driven across these lodes; the first cross cut was driven at 30 fm. west of the shaft 33 ft. north across the lode, and the second cross-cut, 30 fm. west of the first cross-cut, 38 ft. across the lode to the foot-wall granite. Another cross-cut has just been started to also reach the foot-wall granite. Unfortunately no payable tin ground has so far been discovered in any of this development work, although the lode has from time to time shown favourable and encouraging features. The 440 fm. level (see C) has been driven a total distance of 43 fm. west of Wheal Harriet shaft without discovering any payable tin ground. Owing to shortage of labour the driving of this end has had to be suspended. A cross-cut has been driven 36 fm. north of Stray Park shaft at the 314 fm. level (see B), but without, as yet, intersecting any lode although branches of tin-bearing granite have frequently been found. The cross-cut at the 238 fm. level (see A), north of Stray Park shaft, has been driven a total distance of 71 fm. intersecting a lode which for 3 ft. wide produced 40 lb. of black tin per ton. The cross-cut is still being driven farther north, where some branches have been met with, to get into the country granite previous to driving east and west on the lode. This work will shortly be done by boring machines, which hitherto it has been impossible to employ. It is probable that another lode is still farther north, and, as soon as the opportunity occurs, the cross-cut will be continued in this direction.

Tincroft Mines.—This company was formed as the Carn Brea & Tincroft Mines in 1900 to continue the working of a group of old tin mines near Camborne, Cornwall. A year ago the Carn Brea section was abandoned, and shortly afterward the name of the company was changed, and the £1 shares were written down to 5s. In previous issues we have recorded the varying fortunes, mostly adverse, of this company. The report for the half-year ended December 31 last shows that 29,095 tons of ore was raised, and that the yield of black tin was 245 tons, or 18·7 lb. per ton. The receipts from the sale of black tin were £23,402. In addition £1,015 was realized from the sale of low-grade tin concentrate, £8,507 from the sale of arsenic products, and £3,904 from wolfram concentrate. The total revenue was £37,450. The working cost was £37,494, and the lord's royalties £1,146. The development has been pushed, but the grade of the ore disclosed continues to be low.

East Pool & Agar.—This company was originally formed in 1834 to work tin mines situated between Camborne and Redruth, Cornwall. During the years from 1905 onward the development gave poor results, and the yield gradually decreased, with a consequent diminution of the profit and, latterly, of funds available for further development. In 1913 the company was reorganized under limited liability law, and £35,000 new capital was introduced by the influence of Messrs. Bewick, Moreing & Co., who then undertook the management. Since then the known lodes have been further developed, and additional lateral exploration has been done. The success attending the latter work has been recorded in our columns, and the new lode, called the Rogers, has already added substantially to the ore reserves. The report now issued covers the year 1916. During this period, 81,395 tons of ore was raised and sent to the treatment plant. The yield of black tin was 914 tons selling for £94,495, of wolfram 100 tons selling for £17,542, of arsenic 526 tons selling for £12,434, and of copper concentrate 10 tons selling for £173, making a total income of £124,646, or 30s. 7d. per ton. During the previous year 81,426 tons of ore was treated, and the yield of black tin was 597 tons selling for £53,042, of wolfram 127 tons selling for £20,000, of arsenic 804 tons selling for £11,219, and of copper concentrate 15 tons selling for £112, making a total of £84,373. The yield of black tin per ton of ore and the income from its sale was much higher during 1916 than during 1915, but the yield of wolfram and arsenic was lower. The average chemical assay of the ore milled during the year was 21·95 lb. of metallic tin per ton, and that of the tailing was 6·07 lb. The recovery was therefore 72½%. The metallurgical plant worked successfully, the 9 Holman stamps being in operation 94·6% of the total time, with an average duty per stamp of 26 tons per 24 hours. The labour conditions in the mine improved slightly, the total number of shifts worked being 147,936 out of a possible 158,893. This was equivalent to a loss of time of 6·9%, as compared with a loss of 7·8% during 1915. The working cost was £103,208, equal to 25s. 3d. per ton, and with the addition of various small items of income, the profit was £22,485. Out of this profit, £7,527 has been written off previous adverse balances. Two interim and a final dividend, of 5% each, have been declared, absorbing £13,673, making 15% for the year. No decision has been reached with regard to Excess Profits Tax; but it is expected that the 6% statutory limit will be extended in the case of Cornish tin mining as well as to Nigerian and Malayan mining. The report contains imformation relating to the development of the Rogers lode, showing the discovery of large amounts of high-grade ore, as recorded already in our columns.

Associated Northern Blocks.—This company was formed in 1899 to acquire the Iron Duke leases at Kalgoorlie, West Australia. Five years ago, on the approaching exhaustion of the mine, the Victorious property at Ora Banda, 35 miles north, was acquired. In December 1915 the Gimlet leases at Ora Banda were bought. The company also acquired the El Refugio property in Zacatecas, Mexico; this property is in the hands of a lessee, but no work has been done on it. The report for the year ended September 30 last shows that 4,343 tons of ore was raised by tributers at the Iron Duke, and treated at the company's mill for a yield of gold worth £18,856, of which £4,656 accrued to the company; also 47,512 tons of residue was treated by tributers for a yield of £8,480, of which £573 was paid to the company. At the Victorious mine, there is no chance of finding additional ore, and operations are confined to extracting the remaining ore; 16,000 tons was raised during the year, and 3,000 tons then remained to be extracted. Little development was possible at the Gimlet property. At the Victorious mill, 6,064 tons of oxidized ore and 15,951 tons of sulphide ore from the Victorious mine was treated for a return of £31,773, together with 8,763 tons of Gimlet ore yielding £25,957, making a total of £57,730. The accounts show a net profit of £5,363. No dividend has been paid since 1913.

Hampden Cloncurry Copper Mines.—This company was formed in Melbourne by the Baillieu group in 1906 to acquire the Hampden and Duchess copper properties in the Cloncurry district of North Queensland. More recently the Trekelano, Pindora, MacGregor, and other properties have been purchased. Smelting was started in 1911, and at first the matte was sent to the Mount Elliott smelter. Converters were added in 1912, and subsequently the blister copper was sold to German buyers. On the outbreak of war, operations were suspended, but new contracts were soon made. The report for the half year ended August 31 last shows that 50,693 tons of ore was raised from the various properties, and that 57,881 tons was smelted, for a yield of 3,720 tons of blister copper containing 3,673 tons of fine copper, 1,276 oz. gold, and 28,009 oz. silver. The sale of products and the profits in custom smelting brought an income of £368,468, and the profit was £143,816. Of this profit, £70,000 was distributed as dividend, being 20% on the capital, £350,000, and £64,000 was placed to general taxation account. The development has fairly well maintained the reserve. The only notable discovery was on the 300 ft. level of the Trekelano. The results at the lower levels in the Duchess have been disappointing. The reserve of smelting ore was estimated on August 31 at 193,000 tons averaging 8½% copper, of which 66,000 tons was in the MacGregor, 47,000 tons in the Duchess, 30,000 tons in the Hampden, 35,000 tons in the Trekelano, with smaller amounts at the Wallaroo, Answer, and Mascotte. The reserve of concentrating ore was 50,000 tons averaging 3½% at the Hampden, and 56,000 tons averaging 5% at the Pindora. The concentration plant at the Hampden mine is completed, and work will start when it is possible to begin mining the ore.

Exploration Company.—As mentioned in our November issue, this company has written down its capital from £750,000 to £375,000 by reducing the par value of the shares from £1 to 10s. This course was rendered necessary owing to depreciation in the value of the assets in Mexico, the United States, South Africa, and elsewhere. The report for the year 1916 shows a profit of £21,209, out of which £17,957 has been spent on administration, leaving a net balance of £3,251, which added to the amount brought forward from the previous year, makes a disposable balance of £97,709; £37,500 is being distributed as dividend.

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CONTENTS.

EDITORIAL

TECHNICAL societies in America have officially admitted the thin end of the wedge in connection with simplified spelling. For ourselves we prefer to follow the standard set by specialists who have a wide acquaintance with the English language, and for that reason we adopt the spelling and pronunciations of the Oxford Dictionary. In this way we are saved much time otherwise wasted in argument.

THE Minister of Munitions has appointed a committee to investigate the resources of the United Kingdom in connection with the non-ferrous metals of use in time of war. Its constitution leads us to suppose that it is a branch of a bigger committee, awaiting final construction, to deal with the mineral resources of the Empire. Our readers will appreciate our point when they read the list of members: Sir Lionel Phillips, Sir H. Ross Skinner, Dr. Aubrey Strahan, and Messrs. C. W. Fielding, R. J. Frecheville, Edgar Taylor, F. W. Harbord, Frank Merricks, and J. F. Allan.

PAPER shortage is affecting the technical press and the mining companies. For instance, the size of the yearly reports issued by Messrs. John Taylor & Sons are substantially reduced by the omission of the engineers' reports and the plans of the workings. Other companies announce that they are not sending reports of their meetings to shareholders, but are commissioning the daily financial press to attend to this matter. For ourselves, we find it necessary to economize paper by discontinuing the dispatch of magazines to subscribers who fail to remit promptly, and to curtail the number of copies usually held in reserve for future requirements. For the same reason, we have had to postpone publication of the index of the first fifteen volumes of the Magazine.

RESEARCH in connection with the corrosion of copper and brass tubes used in marine condensers is now being conducted at the Royal School of Mines, in a laboratory specially fitted for this purpose. Investigations on this subject were started by the Institute of Metals a few years ago, and much work was done by the committee consisting of Professor H. C. H. Carpenter, Captain G. D. Bengough, and Dr. O. F. Hudson. A year ago facilities were given by the Brighton Corporation for the continuation of these researches at the electric power station belonging to the town. More recently the Department of Scientific and Industrial Research has recognized the national importance of the subject, and has made an annual grant for the establishment of a more permanent home for the research at the Royal School of Mines. This laboratory was formally opened on the second of this month, when the three investigators named above explained the lines on which the research is being conducted.

THE death of Dr. Edward D. Peters removes a great American expounder of mining and metallurgical practice. He was one of the writers who made the *Engineering and Mining Journal* a power in the world, in association with the late Richard P. Rothwell, Dr. R. W. Raymond, and Professor Henry M. Howe. Users of his books on copper smelting may not be aware of the fact that his first edition originally appeared as a series of articles in our New York contemporary, as also did Professor Howe's work on the metallurgy of steel. For the last fifteen years Dr. Peters had been professor of metallurgy at Harvard, in his native city of Boston. He was as successful with the students as he was previously with the more experienced men of the world.

IN accordance with our declared policy of drawing attention to the possibilities of British metalliferous mining, we present this month an article by Mr. L. C. Stuckey dealing with lead-mining in Derbyshire. The author has been for the last few years manager of the Mill Close mine near Matlock, and he has had exceptional opportunities for studying local conditions and the chances of reviving an ancient industry. The decadence of lead-mining was due largely to the great drop in the price of the metal thirty or so years ago, the conditions altering in much the same way as in Cornwall; but water troubles and the exhaustion of the richer or the more easily mined ores were also factors controlling the position. With modern plant and with the improved price much could be done toward re-establishing the mining operations. But it seems to us that a preliminary examination of the district by an experienced economic geologist is advisable. The Mill Close was one of the few mines that survived the long period of depression. It was under capable management, and was controlled by men who understood the district and were not stingy with funds. What can be done at Mill Close in the gloomy days is surely possible now, with a Government awake to the fact that home industries deserve its protecting care.

WE are asked why no mention was made of peat in the editorial last month dealing with Fuel Economy. We omitted its consideration because it is not in use to any great extent, and is not likely to be. It is true that peat is employed as a fuel to some extent. For instance, it is used at one place in Ireland for gas manufacture, and dry powdered peat has been tried in Sweden for steam-raising purposes. Moreover many investigations have been conducted in Canada, Sweden, and elsewhere with regard to its possibilities. But the future application of peat lies in other directions than its use as a fuel. The desire of the trading community to strip the face of the earth of woods, forests, and other storages of vegetable life must be curbed.

WHILE English engineers and trading houses are inclined to listen to the advocates of reform in our system of weights and measures and the adoption of the Metric System, the American manufacturers are organizing a strong opposition to any proposed interference with the present units. The objection to change is based on the cost of preparing new standards of patterns and materials, and on the implied loss of old factors and data of work and costs accumulated from experience both in the factories and in the text-books. A society called the American Institute of Weights and Measures has been formed to protect and conserve the present units, and to combat the "insidious methods employed to foist the Metric System on the country." If they had not said so themselves, we should not have believed that there were so many crusted tories and last-ditchers in America.

THOSE having business relations with Russia express gratification at the political upheaval and the termination of the old autocratic regime. Adversity brings strange partners, and in this case the freed countries of England and France had a unity of interest with the most backward of empires. Germany is merciless to its enemies, but its internal policy, though strict, has been constructively helpful to the community. On the other hand, the Russian method of government has been cruel and oppressive, both internally and externally. From this point of view we can appreciate President Wilson's streak of incredulity in connection with the Allies' claim that they were fighting for freedom. The dawn of day in Russia has entirely changed the conditions, and the American nation now has a clear conscience in ranging itself against the last of the nations that worship the remorseless god of brute force.

STUDENTS of the Royal School of Mines who have gone to the war have often speculated on their chances of eventually becoming mining engineers or metallurgists. In the midst of their other worries they have been anxious to know how their broken courses of study could be completed. The governors of the Imperial College have spent much time and thought in the consideration of this subject. After full discussion it has been decided that no absolute rule can be laid down, but that it will be best to consider the case of each student individually. This decision will be acceptable to the students, for they know that they have sympathetic professors. The official circular advises all students to complete their four years' course, but that they will be given the opportunity of satisfying the tests in less than the full time. Thus the third and fourth years' work may be compressed into one year, by utilizing part of the vacations and by reducing the amount of underground training. It is not considered advisable, however, to remit any of the work of the first and second years. We believe that this is the right decision. In Professor Frecheville the students have a faithful champion. Being not just a pedagogue, but a man of the world and a mining engineer with an unusual range of experience in the two hemispheres, he appreciates the fact that education consists not only of the absorption of information but also of the cultivation of moral and intellectual strength. The ability to manage a mine depends largely on the power to lead, inspire, and control the workers. The war has given the young men this necessary training, it has ripened their judgment, and it has sobered their views of life. And have they not had enough underground experience in the trenches and the tunnels? The students will be encouraged by the knowledge that not only are their professors sympathetic but that the mine owners and the firms of consulting engineers will be keen to secure their services afterwards. No student of the Royal School of Mines, or of the other mining schools in this country, who has been to the war will ever be left begging.

Robson & Crowder versus Elmore.

The early history of the flotation process is gradually being unravelled. Whenever intimate details are published, there are the two inventors, one alleging that the other has annexed his idea, and the other asserting that the new process is not an improvement on the old process but an entire novelty. At the present time, the controllers of Minerals Separation are inveighing against an American inventor and the users of his process for robbing them of the fruit of their labours, while the alleged infringers claim that their process is not covered by the Minerals Separation patents. On this side, Elmores have always asserted that Minerals Separation patents should have belonged to them. Now we have Mr. Hedley D. Crowder writing to the *Mining and Scientific Press* for February 24, and reviving the allegation that some share of the Elmore invention should be accredited to Messrs. Robson & Crowder. This controversy is, of course, not new in this country, but it is no doubt new to most Americans. Mr. Samuel Crowder bought the Glasdir copper mine in North Wales in 1892, but found the ore not amenable to water concentration. His manager, the late Mr. George Robson, accidentally discovered the affinity of oil for pyrite. A machine was made and a patent obtained. Nothing came of the scheme, and Mr. Crowder sold the mine in 1896 to Mr. William Elmore. The correspondence between Mr. Crowder and Mr. Elmore shows that the latter, and his son Mr. A. Stanley Elmore, were fully aware of the oil experiments, and that when Mr. Frank Elmore took out his own patents Mr. Crowder expressed his dissatisfaction that Mr. Robson should have been ignored. The reason for Mr. Hedley Crowder reviving the controversy is to answer certain statements made by Mr. Stanley Elmore in a pamphlet issued last .year, and quoted in our issue of November last. In this pamphlet it was admitted that the Robson & Crowder process was tried at Glasdir, and that the Elmore process was also developed there a year or two afterward. It was explicitly stated, however, by Mr. Stanley Elmore that Mr. Frank Elmore, who appeared on the scene subsequently, received his first impression of the action of oil by personal observation without any previous knowledge of the Robson & Crowder experiments. The sum and substance of this controversy is that, according to Mr. Crowder, Mr. William and Mr. Stanley Elmore knew of the Robson experiments, and that, according to the Elmores, Mr. Frank Elmore did not. This is somewhat in the nature of a *reductio ad absurdum*, and the interpretation of these private and personal matters may be left to the taste and fancy of our readers. What concerns the public is that Mr. Frank Elmore's invention was a step in advance, and that his work brought the principle of flotation within the range of practical application. We now await a controversy between the representatives of the late Mr. Robson and the late Mrs. (or was it Miss?) Carrie Everson, and eventually the resurrection of archives explaining the source of the Everson idea.

Great Boulder Perseverance.

In this issue we commence the publication of a paper on metallurgical practice at the Great Boulder Perseverance gold mine, at Kalgoorlie, West Australia. Our object in presenting this article to our readers is twofold. In the first place, we desire to do honour to the memory of the author, a young man of brilliant promise, but alas! killed in the war. Secondly, the paper contains an unusually detailed account of metallurgical practice at a mine where the costs are the lowest at Kalgoorlie.

Wolfred Reeve Cloutman was a student at the Royal School of Mines from 1908 to 1912, taking his associateship in the latter year and winning also the De la Beche medal, the Murchison medal and prize, and the Warington Smyth medal and prize. He then proceeded on a post-graduate course to the Perseverance mine. In conformity with the rule he prepared a thesis on his experience and results of study during his tenure of the scholarship. It is no exaggeration to say that this thesis was in every way a wonderful production, in style and value far beyond the average. It was in fact a comprehensive treatise on the geology and mineralogy of Kalgoorlie, the methods of mining and development and the mechanical and electrical equipment at Perseverance, together with details of the metallurgical practice. Not only were the notes neatly written and clearly put together, but they were accompanied by sketches of the workings and plant and by coloured drawings of microscopical sections. It was a comprehensive treatise rather than a thesis, and when presented to the Institution of Mining and Metallurgy, the council found that it would occupy as much space as a yearly volume. Under war conditions it was impossible to print it in full, so the Council decided to present it to the Royal School of Mines. The professors at the School and the Council of the Institution agree with us that some public recognition should be made of the admirable work of the deceased student, not only for his sake but also to arouse an emulative spirit among succeeding generations of students. It would not be possible for us, any more than for the Institution, to publish the treatise in full, and in any case many of our readers will already be sufficiently familiar with the geology and minerals of Kalgoorlie and the general mining practice. We therefore decided to print only that part dealing with metallurgical practice. Though books have been written by Mr. Robert Allen and by Mr. Donald Clark on West Australian practice, these were issued before the Perseverance plant was working on present lines; and besides, none of the plants has been described with such details as Mr. Cloutman gives us. We have said that the paper is accompanied by a multitude of drawings. Those attached to this section are mostly pencil sketches, which the author would have re-drawn in ink for publication had he lived. Owing to the current scarcity of draughtsmen capable of interpreting machine sketches we have not been able to reproduce all these drawings, and even those which we do present may be found eventually to be not quite perfect in detail. They serve sufficiently well, however, to indicate the ideas. We greatly regret that we are not able to do justice to the author in this particular.

The Great Boulder Perseverance was the first of the big mines of Kalgoorlie to show an impoverishment of its rich ores. Lake View Consols was the next to feel the pinch, and after that the Associated. They have been survived by the Great Boulder, Ivanhoe, Kalgurli, and Golden Horse-Shoe, and these now are for the most part within measurable distance of the end, though changes of formation as indicated by bore-hole occasionally give hopes of revival. The Perseverance collapse was one of the sensations of 1905. The new controllers placed the management with Messrs. Hooper, Speak & Co., whose resident partner was then Mr. Ernest Williams. This firm reorganized mining and metallurgical methods and conducted a great deal of exploration work. But no more rich ore was found in important quantities, and the history of their work has constituted a struggle for efficiency in the face of decreasing assay-values. The metallurgical plant was remodelled after a fire in 1909, and some substitutions were made. The costs, including all charges and outgoing expenses, are at present about 21s. per ton, a figure which is much lower than those at the neighbouring big mines. Though there is an extensive ore reserve, both broken and unbroken, large portions are of too low a grade to meet expenses and the end is therefore approaching rapidly. From the point of view of the experienced mining engineer these records of practice at the Perseverance may appear to be elementary in parts. On the other hand the average reader of the Magazine, who is desirous of obtaining an intelligent knowledge of mining and metallurgical procedure, will find much that is instructive. Finally we may congratulate the engineers and the company on their willingness that the full details of their work shall go forth to the world.

Fertilizer Problems.

A well known mining engineer and geologist writes from Canada to tell us that he is doing everything he can to help to increase the production of both metals and food-stuffs. The average reader may consider this association of mining with agriculture as distinctly quaint, and even reminiscent of the cross purposes of the National Service. A few moments' thought will show, however, that the study of the nature of soils is a branch of applied geology, and that their enrichment comes within the scope of the mining engineer and metallurgical chemist. This association of the production of food-stuffs with the miner and geologist is not the only interesting feature of present conditions, for the supply of artificial fertilizers is now dependent on the requirements of the Ministry of Munitions in the matter of explosives. The Department of Agriculture is exhorting us to get back to the land, and to adopt strenuous or intensive methods of raising crops; but in so doing it is coming into partial clash with the Munitions Department, which requires the raw materials of the fertilizer industry for its own particular purposes.

The science of agriculture has not progressed far as yet, and the chemists are still in the dark as to many of the effects of the addition of fertilizers. On the other hand, the farmers keep the results of their experience to themselves, so that useful knowledge is not spread among the populace. Except to press on our Government the desirability of extending the sphere of agricultural education, we do not intend here to refer to the food problem from the point of view of the farmer or food producer. The intention of this article is rather to show the connection of soil preparation with the business of the mining and metallurgical engineer and the geologist. The preparation of land for farming consists of two steps, first the improvement of the physical condition, and second the introduction of fertilizers which stimulate the vegetable growth. Instances of the first step are the breaking of heavy clay ground by the addition of lime and ashes, and the addition of binding materials to sandy soil so as to protect it from æolian effects and to preserve the moisture and soluble fertilizers. The addition of vegetable and animal matter also serves to improve the general condition of the soil, as well as to provide the stimulants. The services of the pioneer geologist in a new and unpeopled country would be of as great value to the intending settler as to the prospector for minerals, for a report on surface soils and opportunities for improving them would give the necessary information to the intelligent emigrant before he decides to make the venture.

Subsequent to the study of the physical condition of the land it becomes necessary to consider the other constituents of the soil required by the crops. All vegetable growth demands the presence of phosphates, nitrogen compounds, and potash salts in the soil. These are in the ordinary course of events supplied by returning animal and vegetable refuse to the land. In a little self-contained community that has formed a settlement on good virgin soil these constituents would pass continuously to and from the soil. In our more complex civilization the products of the soil go to all the ends of the earth, and the refuse never returns, being burnt and scattered or delivered to the ocean. Thus the exhausted soil has to be replenished in other ways, and resort is made to the artificial fertilizer prepared from minerals. The establishment of industries producing these materials has made it possible to introduce more of these constituents of the soil than it originally contained, in both self-contained and exporting agricultural districts, so that it is now possible to increase the yield per acre in a marked degree. This intensive culture has been adopted in many countries, but Great Britain has lagged behind. The producers of sulphate of ammonia, for instance, have found readier markets abroad than at home. With the export of fertilizers now stopped, and with a practical and scientific agriculturist at the head of the Government Department, there is hope that old prejudices will be swept away and that the yields per acre will be substantially increased.

As we have already mentioned, the compounds of nitrogen, phosphorus, and potash are required in the soil for plant life. Supplies of nitrogen and phosphates come from animal refuse, and potash and phosphates from burnt vegetable refuse. Potash and phosphates originally came from the igneous rocks, and nitrogen from organic compounds and from the air. The first artificial nitrogenous fertilizer of importance was sulphate of ammonia, which is produced by absorbing in sulphuric acid the ammonia contained in gases evolved by the distillation of coal. It has been a valuable by-product at the gas works, and at the carbonization works of the coal-tar industry, and it is now also obtained from the ammonia of blast-furnace and coke-oven gases. The increasing use of gaseous fuel affords another important source of this fertilizer. We mentioned at the beginning of this article that the fertilizer industry clashed with the manufacture of munitions. The difficulty in this case is to obtain the necessary sulphuric acid, for which the Munitions Department has first call in connection with the production of explosives. The next nitrogen fertilizer to be mentioned is nitrate of soda, which is exported in great quantities from Chile. This substance is also used for the manufacture of nitric acid, which is in such great demand at present for explosives. It has never been possible to ascertain the relative proportions of nitrate used for these two purposes, but we can guess that at the present time very little is used as a fertilizer. Two other commercial nitrogen products have recently been introduced as fertilizers and as raw materials in explosive manufacture. In both cases the nitrogen is obtained from the air by fixation in the electric furnace. In one case nitric acid is obtained by direct reaction between the constituents of the atmosphere, and the fertilizer is produced by the action of the acid on lime. In the other case cyanamide is produced by the action of nitrogen on calcium carbide, and its virtue lies in the fact that on contact with water it yields ammonia. In America this substance is largely used as a fertilizer. An English company produces it in Norway and Sweden, and the ammonia thereby obtained is converted into nitric acid by the contact process, and the output delivered to the Government as nitric acid and nitrate of ammonia. These electric processes are used in Germany for the production of nitric acid now that Chile nitrate is unobtainable. Other processes are also in use in Germany and elsewhere for fixing atmospheric nitrogen, notably the Haber synthetic ammonia process, but as we gave details in our issue of June 1913, we need not say more now. Before leaving the subject of nitrogen in its relation to plant life, we may mention that it is only recently that the absorptive power of the plant for the nitrogen of the air has been demonstrated, and that micro-organisms are the agents for this reaction. This principle has been applied in a somewhat similar manner for producing nitrogen compounds suitable as fertilizers from vegetable substances such as peat.

Of phosphatic fertilizers the soluble salts produced by the action of sulphuric acid on rock phosphates have had wide application and have proved highly beneficial. At first, this superphosphate was a primary product depending for an outside source of acid for the treatment, but of recent years it has also been a by-product at chemical works and smelters, the process being introduced for the purpose of getting rid of surplus sulphuric acid which was usually made under compulsion in order to prevent the escape of sulphurous fumes into the atmosphere. The use of superphosphates is strongly recommended in this country at present, but here again the difficulty of the sulphuric acid supply arises. In all probability the use of acid sulphate of soda, a waste product in nitric acid manufacture, will prove a good substitute for sulphuric acid in this connection, and probably also in the case of sulphate of ammonia. Another important source of phosphate is the slag produced in the basic open-hearth process of steel-making. An increasing proportion of low-grade iron ores now treated, especially those of primary magmatic origin, contain phosphorus, and these offer an important source of fertilizer. At the present time, the chemists and agriculturists are not united as to the nature of the benefits of basic slag, but no doubt these questions will be settled before long.

We finally come to a consideration of the potash salts. The salts present in the soil have come from the disintegration of igneous rocks, and the fertilizers introduced usually came from burnt timber or from sea-weed. The discovery of enormous deposits of potash salts at Stassfurt, Germany, gave an impetus to the use of potash as a fertilizer, and the incidence of the war, with the consequent cessation of supplies to various countries, has caused inconvenience. In many quarters the scarcity of potash salts has revived the sea-weed industry, and has stimulated research for a process for producing them in commercial quantities direct from igneous rocks. There is considerable doubt, however, as to the actual value of potash, and many authorities hold that though it is a necessity for plant growth it is not necessarily always a stimulant. There appears to be no doubt that it is beneficial for plants yielding sugar, such as barley and beet; otherwise there is no unanimity among disinterested experts. There is in fact a suspicion prevalent in some quarters that the potash cult has been pushed a little too far.

The use of fertilizers is a never-ending subject for discussion. One of the points is the action of each fertilizer on each particular plant, and also as they are roots, cereals, or grasses; and another is the application of each in each case according to the character of the soil. A further problem relates to the action of the constituents of the soil on the fertilizer and of the good or bad results of the mixture of fertilizers. Also much could be said of other minerals that are of value under certain conditions, such as salt and other sodium salts. But enough has been said on the main point, and to go farther would bring us into the domain of agriculture pure and simple. It is best therefore to stop before we exceed the bounds of the miner and geologist.

The Development of Central Africa.

Time and time again has Mr. Robert Williams been blamed for secrecy in connection with his plans for the development of Central Africa. His many critics will be put to the blush when they read his outline of the history of his negotiations, appearing in the little monthly paper published by the Overseas Club. They will see that it was no more possible to give reasons for his silence than to give details of his work. The time has gone by for hiding Imperial schemes for fear of raising the opposition of the British Government, and of offending the susceptibilities of the Germans; but much still remains to be done in the way of stiffening the attitude of those in control of the destinies of this country and of preserving for the Empire the benefits accruing from the activity of our pioneers. Mr. Williams is now free, on the one hand, to give the back history of the Tanganyika Concessions and its subsidiary enterprises, and, on the other, to call public opinion to his aid lest the work shall have all been in vain.

Mr. Williams was one of Cecil Rhodes' trusted friends who helped him in his plans for the expansion of Empire. Rhodes' dream was the building of the Cape Town to Cairo Railway, and as it was obvious that the construction could only be effected in stages as conditions warranted, it was necessary to discover mineral or other resources that would create a demand for transport. Mr. Williams organized more than one exploring expedition, one of them under the leadership of the late Mr. George Grey, the brother of Viscount Grey of Falloden. They were rewarded by the discovery of the vast copper deposits of Katanga in the southeast corner of the Belgian Congo State. Rhodes had been refused help by the British Government for the continuation of the railway northward, and he had been blocked by the Germans in his scheme for carrying the Cairo line through Tanganyika territory. The Katanga discovery provided a possible alternative route through Belgian country. Mr. Williams negotiated an agreement with King Leopold for the construction of the line through the Congo to the Nile. Unfortunately the late Alfred Beit, who had done so much to finance Rhodes' railways, made such a big demand for a share in the mineral rights for the Rhodesian Railways that the scheme was made impracticable and thus had to be dropped. Shortly after this, Cecil Rhodes died, but Mr. Williams continued his negotiations with King Leopold and eventually the line was built connecting Katanga with the Rhodesian railways. Mr. Williams had met so much opposition in Brussels from German agents, and was subsequently pursued by such crippling propositions for the supply of German capital for railway extensions that he came to the conclusion that Central Africa would have to be developed by some railway built in a direction outside the sphere of German influence. Thus he was impressed with the possibility of approaching Katanga through the Portuguese territory of Angola, making use of the port of Benguella. Investigations proved that Benguella is an open roadstead little adapted as a modern port. Explorations by Mr. Livingstone Learmonth, however, put a different complexion on matters, for they revealed the existence about twenty miles north of an excellent natural harbour at Lobito Bay. Taking wisdom from his experience with the Germans at Brussels, Mr. Williams decided to keep his own counsel in dealing with the Lisbon Government, especially as there was a sort of secret understanding between London and Berlin that Angola should be reckoned a German sphere of influence, in spite of the fact that it was Portuguese territory. Acting with great promptitude Mr. Williams, in 1902, secured the concession for building a railway from Lobito Bay to the Central African highlands. The transaction was done in his own name, in order to avoid delay and leakage of information, and the transfer to Tanganyika Concessions was only effected when everything had been completed. Mr. Williams thus put a spoke in the Germans' wheel. No international diplomatic representations could upset the railway concession, so the Germans altered their tatics and attempted to capture the line by financial methods. It is a matter of public knowledge not only that there was no assistance for Mr. Williams forthcoming from the British Government but that private capitalists had no faith in our Government's attitude as regards political support. Thus it happened that on the outbreak of war the Benguella railway was only partly constructed from both ends, and that absence of funds had postponed its completion. All this time the Germans were offering capital with their usual insistence, but Mr. Williams was deaf to their proposals. The foregoing gives briefly the political difficulties encountered by Mr. Williams. He still has a campaign of preservation to conduct. At the present time there is nothing to prevent the friendly nominees of Germans from buying shares in the open market so as to secure control of both the Benguella railway and the Tanganyika Concessions. Thus after the war the Germans would be firmly esconced in Africa, in spite of the fact that blood and treasure have been spent in driving them out. This course has already been taken by German sympathizers in connection with the Nyassa Consolidated Company, an English company controlling a Portuguese corporation which owns a great harbour and railway concessions north of the Zambesi. If the British Empire is in the future to be for the benefit of the British, this state of things must be altered. The English politicians may evince their usual hesitancy and the English lawyers may still worship the sanctified precedents of international law, but the practical men from Africa and from the other overseas dominions will see that these intolerable conditions are changed.

REVIEW OF MINING

Introductory.—The war draws its hold still tighter on our lives and work. The clean sweep made of irresponsible autocracy in Russia and the entry into the fray of the free republic of the New World mark a great epoch of history. The appointment by the Minister of Munitions of a committee to investigate the British resources of the non-ferrous metals has been received with gratification, and a wider committee to discuss the mineral resources of the empire will be equally acceptable. In the metal markets, copper has settled down, under Government control. The demand for tin has increased lately, and the price has accordingly hardened. This metal has at last come under the influence of war conditions. In the mining market the chief point of interest has been the absorption of the Neumann group by the Central Mining and Investment Corporation.

Transvaal.—Two months ago we recorded the absorption of the Robinson group of mines, namely, Randfontein Central and Langlaagte Estates, by the Barnato group. Another similar deal has this month been made whereby the Neumann companies are taken over by the Central Mining & Investment Corporation. It has been known for some years that the late Sir Sigmund Neumann desired to relinquish his holdings. Since his death the arrangement of a suitable price will have been easier. The producing mines on the Rand belonging to the Neumann group are the Consolidated Main Reef and the Main Reef West in the middle west, the Wolhuter in the central part, and the Knight Central and Witwatersrand Deep in the middle east. None of these mines are among the stars of the Rand, though Consolidated Main Reef, Wolhuter, and Witwatersrand Deep are steady producers. Other companies are the Cloverfield and Rietkuil in the far east Rand and the Marievale Nigel at Heidelberg. The Vogelstruis Deep is being wound up. The Witbank Colliery belongs to the group, as does also the Andrade Mines which operates a gold dredge in Portuguese East Africa.

The yearly reports of Randfontein Central and Langlaagte Estates, recently taken over from Sir J. B. Robinson by the Johannesburg Consolidated, show the influence of the new control in the curtailment of dividends and the holding of an adequate balance for necessary reorganizations of work. Randfontein Central showed quite a respectable distributable balance of £402,570 on the year's work, owing to greater care in the selection of ore. The whole of this balance was, however, carried forward.

Last month we recorded the commencement of milling at Springs Mines. The directors have decided to further strengthen the financial position by creating 500,000 new shares, which will be issued whenever suitable opportunity arises for utilizing additional capital to advantage. The intention is no doubt to be prepared to bid for adjoining properties when the leases are offered.

In the middle of March the extension of the Geduld plant was put in commission. The capacity is thereby raised from 25,000 to 40,000 tons per month.

In our issue of February we recorded that the Oceana Development Company was about to let a contract for boring on its farms Eendracht and Koppieskraal, northwest of Heidelberg. It is now announced that the other party to the contract is Mr. G. R. Bonnard, who will find the funds for the boring operations. Mr. Bonnard is well known as the champion of the Amalgamated Properties of Rhodesia in the famous lawsuit against the Globe & Phœnix. While writing of boring in the Far East Rand basin, we may record that the borehole on Spaarwater farm, adjoining the Eendracht, and controlled by Mr. J. Dale Lace, has intersected a reef at 2,500 ft. showing a width of 35 in. Unfortunately the sectional assays of the bore are low, ranging from traces to 2½ dwt. per ton.

The insurance of South African gold and diamonds in transit is to be undertaken from within the industries, instead of relying on the ordinary insurance markets. This new undertaking is being arranged by Mr. S. B. Joel, who considers that the rates at present charged, about 5%, are far too high. The new company is to have a capital of £2,000,000. In all probability the scope of the company will be extended beyond South Africa.

Much has been heard lately of new alluvial diamond diggings on the Orange River in the district of Aliwal North. Dr. P. A. Wagner has visited the district and issued a report. We hope to be able to give extracts from his report next month.

Taxation in the Union of South Africa is to be rearranged. The war levy on the gold mines will be withdrawn and a new tax substituted, which will apply also to other commercial ventures as well as mines. There will be a 5% tax on company incomes and a dividend tax of 7½% as well. During the war the gold mines will pay 10% dividend tax. Other companies will be subject to a 25% excess profits tax during the war and for six months afterward, but the gold mines will be exempt from this tax. The new arrangements will not affect the gold mines to any extent.

Tin mining in the Transvaal is suffering setbacks at present. A few months ago it was announced that Zaaiplaats is in a bad way. Now comes the unwelcome news that the development at Rooiberg is disappointing. The ore reserves are being rapidly depleted, and it is difficult to keep the mill working at full capacity. The board is considering the advisability of re-treating slime residue, of which there is an accumulation of 50,000 tons averaging 1% metallic tin. This work can be undertaken at little expense, as it is only recently that a slime plant was erected. With the profits obtained from this source, and with the aid of money in the reserve fund, it will be possible to undertake extensive exploration in parts of the property not hitherto prospected.

Rhodesia.—The output of gold during February was worth £289,734 as compared with £296,113 in January and £313,769 in February 1916. The Cam & Motor has fallen off again, and the Globe & Phœnix continued to decrease its rate of output. Golden Kopje has arrived at its end and the final clean-up is being made.

West Africa.—The output of gold during February is reported by the West African Chamber of Mines as being worth £104,892, as compared with £131,665 in January and £137,739 a year ago. The official figure is the lowest since 1911 and the fall is quite unaccountable. In fact the individual returns from the chief mines indicate that there is a mistake somewhere. These returns are as follows: Abbontiakoon £14,007, Abosso £14,227, Ashanti £40,322, Cinnamon Bippo £8,449, Prestea Block A £30,233, Taquah £13,918, total £121,206. Further explanations are expected.

Australasia.—Developments at the Mount Read and Rosebery zinc-lead mines, Tasmania, have given satisfactory results and the diamond drills have proved the existence of large reserves. As regards a source of electric power, the manager of the Tasmanian Government Hydro-Electric Department has made an examination and has decided to build a dam 100 ft. high across the King River, whereby a storage suitable for 30,000 to 40,000 hp. will be created. As will be remembered, these mines came under the control of the Mount Lyell company six or more months ago.

At one time the policy of the Australian Government of requiring all ores to be smelted in the Commonwealth threatened to ruin the Costerfield antimony mines, near Heathcote, Victoria. This cloud has blown over, and the concentrate is still being shipped to England to be treated by the St. Helens Smelting Company. During 1916 the output of concentrate was 3,300 tons obtained from 12,380 tons of ore. Minerals Separation flotation plant is being erected as a substitute for the slime tables.

India.—The most encouraging report from the Kolar group of gold mines comes from the Nundydroog. The output of gold was the highest on record and the reserve has been increased during the year. Developments have been encouraging in the 3,500 ft. level in the Oriental section and in the 3,500 ft. and 3,650 ft. levels in Kennedy's section.

The Ooregum also presents a good report for 1916. The yield of gold, £384,302, was the highest on record. The ore reserve has been increased by 53,000 tons, the figure now standing at 420,000 tons, but unfortunately the lode is disturbed at the 54th and 55th levels in Bullen's, the best section of the mine. Improved metallurgical methods have been introduced lately and the percentage of recovery has been thereby increased.

At the Mysore mine the superintendent is able to report that the developments in depth in McTaggart's and Ribblesdale's sections put a better complexion on the continuance of ore in depth than was the case a year ago. The Edgar vertical shaft is expected to be down to 3,825 ft. next month, below which it is not to be carried at present; this point will be 116 ft. below the 51st level. McTaggart's vertical shaft will shortly be down to a depth corresponding to the 44th level, and then the ground between this and the 39th levels will be developed. A recent new enterprise at the Mysore is the erection of a re-grinding plant for re-treating the old dumps left in earlier years. This should be completed before long.

Malaya.—The Wickett group of tin-mining companies operating in the Federated Malay States, and controlled at Redruth, show good results in the yearly reports just issued. The Gopeng is now reaping full benefit of the high-pressure water brought from the Kampar river.

The yield of tin concentrate for the year ended September 30 last was 1,083 tons, as compared with 681 tons the year before. The income was £110,451, and the total expenses were only £33,700. Out of the profit, £20,384 was written off, and £8,000 was placed to reserve. The shareholders received £59,365, being at the rate of 15%. The Tekka-Taiping company, operating at Larut, reports that the pump dredge went out of use in May 1916, and that the bucket dredge, which started in September 1915, has proved a great success. The bucket dredge has treated ground that has yielded an average of 1·3 lb. black tin per yard, bringing an income per yard of 10⅝d., at a cost of 3·7d. per yard. The company's profit for the year ended October 31 was £48,272. The shareholders received £12,991, being at the rate of 20%, and £14,657 was written off machinery account.

Cornwall.—The directors of Geevor have combined with others to purchase a diamond drill. The new pumping and air-compressing plants for the Wheal Carne section of the mine have been completed. The progress report shows that during the twelve weeks ended February 28, 5,432 tons of ore was milled for a yield of 73½ tons of black tin, being an extraction of 30 lb. per ton.

Last month we referred to the excellent prospects at East Pool and the distribution of a dividend. The rich ore in the Rogers lode had helped to make the profit. At South Crofty dividends have been paid without any such aid, a fact which speaks volumes for the ability of Mr. Josiah Paull as a mine manager. The cross-cutting in the direction of the Rogers lode is nearly completed, and everybody is anxiously awaiting news as to whether the lode continues into South Crofty ground, and if so what its width and content will be.

The Levant mine continues to be worked at a loss. Three months ago the loss on the quarter's work was £876, which was attributed to a breakage of plant; the quarter just ended shows a loss of £391, in spite of a return to normal tonnage. The yield was 43 lb. per ton, but at this mine the costs are necessarily high.

Our Camborne correspondent referred last month to the re-opening of the Parc-an-chy wolfram mine east of Redruth, and he wrongly stated that Messrs. Edgar Allen & Co. had done some work at this mine a few years ago. As a matter of fact, it was the Wheal Gorland, not far away, that the Sheffield steel firm tried, unfortunately finding little ore worth extracting. Parc-an-chy is evidently a promising producer, for the mining engineer sent by the Munitions Department confirmed Mr. A. Spencer Cragoe's estimate, and recommended the advance by the Government of £10,000 on loan as working capital. There are many other wolfram properties in Cornwall that might be re-opened.

Canada.—The Ontario Nickel Commission has issued its report. The recommendation is that nickel should be refined in Ontario, preferably in the electric furnace. The view is expressed that the output of the mines in the Sudbury district could be easily doubled, and that the resources are sufficient to meet all the requirements of the Empire. We await the arrival of the text of the report in this country.

The preliminary report on the mineral production of Canada for 1916, made by Mr. John McLeish, is given elsewhere. The output of gold was 926,963 oz. worth $19,162,025, a slight increase over the production of 1915. Decreases in the contributions of British Columbia and the Yukon were more than off-set by a 20% increase in the output of the Northern Ontario mines. Silver shows a fall in quantity, but an increase in value, with a production of 25,669,172 oz. valued at $16,854,635, as against 26,625,960 oz. valued at $13,228,842 in 1915. The output of nickel from the Sudbury ores has been supplemented by a small tonnage from the Alexo mine in Timiskaming, and by the nickel recovered as a by-product in the treatment of the Cobalt silver ores. The total production of nickel was 82,958,564 lb. valued at $29,035,497, an increase in quantity of 21·5%.

The ore reserves at Hollinger, Porcupine, at December 31 were estimated as containing $34,185,535. At the annual meeting on March 6, Mr. P. A. Robbins, the manager, reported that subsequent development had increased the ore reserves by at least one million dollars. He further stated that the extension at the mill could be completed in six weeks provided they could get delivery of the machinery ordered, but that owing to increased prices, the cost would exceed by quite $200,000 the original estimate of $600,000. At the Dome Mines the new Hardinge mill will be completed shortly. This is expected to bring the tonnage treated per month to 55,000 tons. Recent development at depth is stated to have considerably improved the average grade of the ore. The power transmission line to the Kirkland Lake district is now in operation and a season of great activity is anticipated. The purchase of the Kirkland Lake property by the Beaver Consolidated, of Cobalt, has been completed, and the first instalment of the purchase price of $308,000 has been paid. The Callow oil-flotation plants at the Coniagas, Buffalo, and McKinley-Darragh mines at Cobalt are working satisfactorily, and the sysem is reported as an assured success.

United States.—The flotation battle continues unabated. When the decision of the Supreme Court was issued establishing the Minerals Separation patent based on less than 1% oil, we pointed out that the royalty demandable would depend on the extra cost of the oil required to bring the amount used over 1%. The Butte & Superior Company, which was the loser in the case, has decided to regularize its position by using over 1% of oil, and has issued a statement to the effect that the results are "satisfactory in all metallurgical respects." Whether the virtue of the fraction of 1% of oil consists in anything other than economy has never been independently demonstrated, though Minerals Separation claims that there is a substantial difference in the action of the exceedingly thin film of oil. It is obvious that there are many devious ways, as well as the normal way, of dodging that arbitrary 1%.

The copper producers in America are supporting their government in its war policy in a practical way. They have decided to supply 50,000 tons during the next twelve months at a price based on the average of the ten years from 1907 to 1916, which works out at 16⅝ cents per pound, or about half the current quotation.

Progress in the manufacture of artificial fertilizers is exemplified by the new departure of the American Cyanamide Company in purchasing phosphate deposits in Florida from the Amalgamated Phosphate Company. The object is to manufacture a fertilizer containing both ammonia and phosphorus, having a composition analagous to guano.

Mexico. — The cyanide shortage at Santa Gertrudis is being gradually overcome. The mill was closed during February, as already recorded, but the latest cable reports a resumption at the rate of 500 tons per day, that is, about half capacity. Contracts are now being arranged whereby, it is hoped, the normal capacity may be reached in June.

South America.—The report of the Aramayo Francke Mines, operating in southeast Bolivia, for the year ended May 31, 1916, published last month, shows that the production of black tin was 2,094 tons obtained from 38,626 tons of ore, being a yield of 5·4%. The production of tinny wolfram was 148 tons, obtained from low-grade ores. The output of bismuth is not given. As is well known, bismuth is one of the "secret" metals. The marketing of the company's various products is difficult at present, owing to lack of transport in Bolivia and to the uncertain state of sea communication. Of the several mines, Chocaya and Tasna are developing well, but the reserves at Chorolque are diminishing.

The development of the Frontino and Bolivia Company's gold mine in Colombia, as planned by Mr. W. Pellew-Harvey and conducted by Mr. A. N. Mackay, has been giving good results lately. On the 12th and 13th levels, blocks of high-grade ore have been disclosed, and the reserves have been increased. The diamond-drill has not discovered anything of importance so far, and has done nothing except prove the correctness of the previous diagnosis.

Spain.—The high price of copper has brought back the Cordoba Copper Company to the list of dividend payers, £20,000 being distributed for 1916, at the rate of 10%. The assay-value of the ore continues to decrease, the present reserve averaging about 2·4%. Owing to calcite in the gangue, any ordinary flotation process cannot be used, so the Murex magnetic process was installed for the treatment of some of the mill products. The percentage of recovery by concentration is still only 75%. A year ago the prospects as regards ore reserves were gloomy, but recent discoveries have improved the position. The ore is to be followed in depth when additional pumps and winding engines are installed.

The Esperanza Copper & Sulphur Company presents a good report for 1916. The profits of the past year or two have been utilized for the extinction of the debentures, and the company, having a capital of only £350,000, may now look forward to a period of substantial dividends. The ore reserves have been increased, and stand at over five years' output.

The Rio Tinto Company reports a net profit of £1,986,563 for 1916, out of which £81,250 has been paid as preference dividend at the rate of 5%, and £1,781,250 as dividend on the ordinary shares, at the rate of 95%. The rate of the ordinary shares compares with 55% a year ago, and has only been exceeded once, namely, in 1906, when 110% was paid. Companies operating in Spain do not find it advisable to publish details of the year's work, and under war conditions the reports are even briefer than usual. In his speech at the meeting of shareholders, the chairman, Mr. C. W. Fielding, made brief but interesting mention of the new housing schemes for the workmen, at the mine and at the port of Huelva.

LEAD MINING IN DERBYSHIRE

WITH SPECIAL REFERENCE TO

THE MILL CLOSE MINE.

By L. C. STUCKEY, A.R.S.M., M.Inst.M.M.

HISTORICAL.—Lead mining in Derbyshire has been carried on for a longer period than any authentic records inform us, but there is no doubt that the Romans both mined and smelted lead during their occupation, and it is most probable that the Romans merely continued operations which they found in progress. So lately as 1877 a pig of lead was found on Cromford Moor inscribed "IMP. CAES. HADRIANI. AVG. MET. LVT." dating between 117 and 138.A.D. Three other Roman pigs are known, two of which were found near Matlock, one bearing the inscription of Emperor Claudius about 50.A.D. That the mines at Wirksworth were worked in the eighth century by the Saxons is proved by the sending of a leaden coffin and shroud to St. Guthlac, at Croyland, in Lincolnshire, by Eadburga, daughter of Adulf, King of the East Angles, and Abbess of Repton, the mines being then the property of the nunnery. (Leland Coll. 11 590).

Camden (Britannia p. 420) gives three lead mines in Domesday, besides others at "Bakewell, Ashford, and Chrich." The Odin mine at Castleton is generally considered to be the oldest in the county, by Farey (1811) and Pilkington (1789).

The mineral districts correspond to the outcropping limestone throughout the county, extending from Wirksworth and Crich in the south, to the High Peak in the north. For many years this wild and semi-mountainous district must have remained almost inaccessible to those unconnected with the lead industry, and in course of time the inhabitants acquired special characteristics of independence and readiness of resource, which may be traced in their descendants to the present day.

These Derbyshire lead miners, dating from "a time whereof the memory of man runneth not to the contrary," gradually established customs under which they worked, and these customs were recognized by the Crown, which assumed mineral rights for nearly the whole of this metalliferous district, a few private mineral liberties, of which Crich was probably the richest and most important, being excepted.

In the Miners Guide or Complete Miner (reprint from Hardy & Houghton) published at Wirksworth in 1810, there is a copy of the Inquisition held in the 16th year of the reign of Edward I. (1288) to define the liberties claimed by the miners. The powers of the "Berghmaster" and the "Berghmote Court" were confirmed sufficiently to make the miners independent of any other authority. "Moreover they say that if any miner shall come to any accident death upon the mine he shall be buried without view of the Coroner of the County by view of the miners, and if anyone shall be convicted of simple trespass he shall give for an amerciament eight pence and he shall pay it the same day otherwise he shall double it from day to day until it comes to five shillings and fourpence. And if anyone shed blood upon the mine he shall pay five shillings and fourpence the same day, otherwise by doubling it daily until it come to one hundred shillings, and if anyone be convicted of trespass underground he shall give for an amerciament five shillings and fourpence and

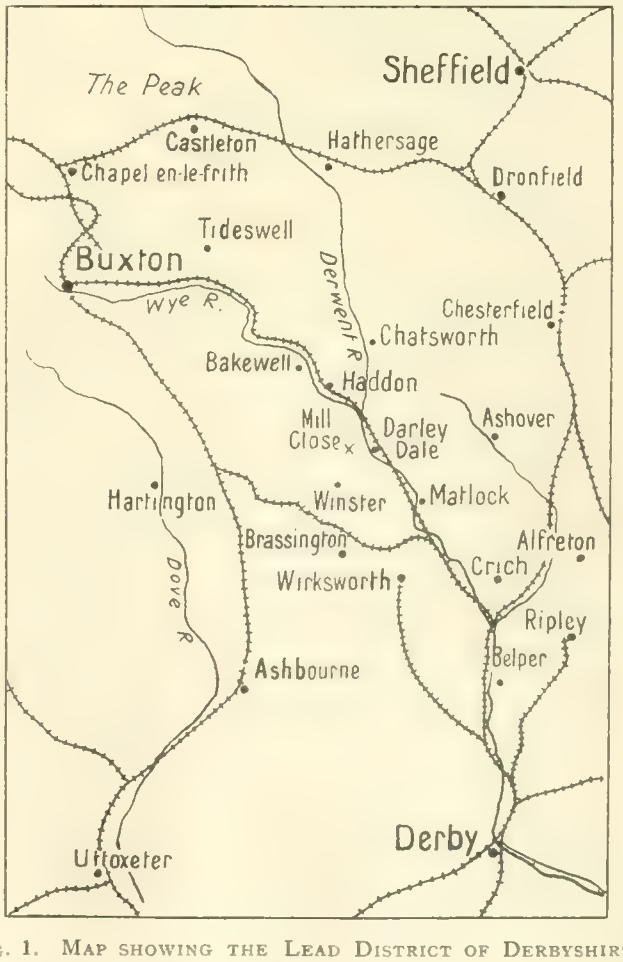


FIG. 1. MAP SHOWING THE LEAD DISTRICT OF DERBYSHIRE.

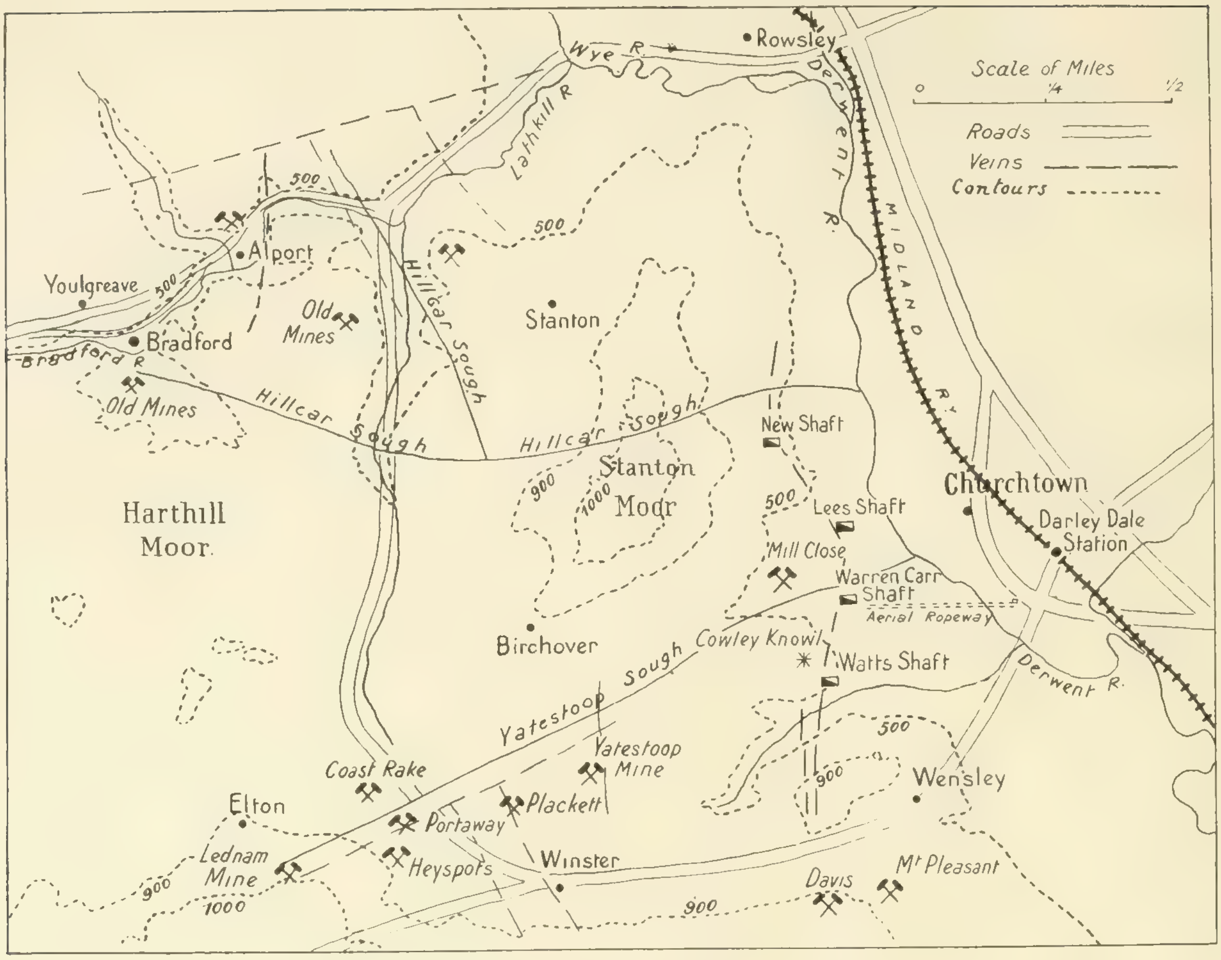


FIG. 2. CONTOUR MAP OF THE MILL CLOSE AREA.

shall render to his fellow the damages which he shall have sustained."

The customs were handed down from generation to generation of Derbyshire lead miners with no sanction save that of antiquity, until the Government took cognizance of them by embodying all such as were necessary for the carrying on of lead mining within the areas in which the Crown claimed mineral rights "(The King's Field)" in the Derbyshire Mining Customs Acts of 1851 and 1852.

These customs provided for the appointment of a Barmaster, who, with the assistance of juries summoned as required from among the working miners, dealt with all matters affecting the industry. Mr. A. H. Stokes gives full details of the customs in a paper on Lead and Lead Mining in Derbyshire, read before the Derbyshire Institution of Mining, Civil & Mechanical Engineers, 1880, together with a reprint of Manlove's clever jingling rhyme which was first published in 1635.

The most important of the customs still in force and in statutory authority is that any person desiring within the King's Field to mine for lead ore may apply to the Barmaster for permission to search. Having found a prospect, he dresses a " dish " of ore from the mine which he takes to the Barmaster as evidence; the particulars are entered in the Barmaster's books and the mine is "registered." The Barmaster then sets out on the surface a site for the dressing plant, and for a pond to hold water for dressing, and rights of way for access to and from the intended mine. All this is done on the surface of land irrespective of ownership, the unfortunate owner receiving as compensation for the injury to his property the proceeds of a given length of the vein when worked. The Barmaster is not allowed, however, to sanction mining under houses, gardens, or churchyards. The ownership of all mines in the King's Field depends upon the working title merely, and if a miner fails to work his mine after three weeks' notice so to do by the Barmaster, his interests may then be made over to any other applicant.

One of the old customs (which has not received the sanction of Parliament) shows that savage punishments were inflicted upon anyone found guilty of stealing lead ore from a mine. An offender for the third time was punished by having a knife stuck through his hand into the wooden windlass over the shaft, the thief being left there to starve to death unless he preferred to liberate himself by "cutting loose his hand." This delightfully "kultured" phrasing reminds one of more modern frightfulness.

It is stated by Hoover (Agricola, footnote

p. 85) that "as well as having the distinctively Saxon names for some of the mines, the customs there are of undoubted Saxon origin, and as such their ratification by the Normans caused the survival of one of the few Saxon institutions in England." It is doubtful whether we do not owe the idea of the Apex Law to the mining right granted under these customs.

The dressed ore was sold by measure in standard dishes of 472 cubic inches, nine dishes constituting a "load." Every thirteenth dish was the King's property and was called the "lot"; but this has now been reduced to $\frac{1}{25}$th of the dressed ore, which is paid to the Duchy of Lancaster. The price taken for lead in calculating these royalties is that of the "L.B." or Locke Blackett, brand. This price is, however, usually considerably above the actual price obtainable for the lead produced. A standard dish made of brass and preserved at the Moot Hall, Wirksworth, was given to the miners and merchants in the fourth year of King Henry VIII., A.D. 1513, and is still maintained.

Fire setting, duly regulated, was used to break ground and drive the levels until about 1640, when drilling and blasting were introduced by German miners brought to Ecton copper mines by Prince Rupert.

GEOLOGY.—The geology of lead-mining districts of Derbyshire is practically confined to the disposition and relationship of the Carboniferous Limestone in which the veins become productive. The great anticlinal axis exposing the limestone runs slightly west of north through North Derbyshire to the West Riding of Yorkshire. To the west of this lie the coal measures of Lancashire and North Staffordshire, while on the east are the coalfields of Yorkshire and Derbyshire; the upheaval has been greatest in the north, bringing a large dome of limestone to the surface. Passing either east or west from the limestone we meet first the Yoredale Shales and then the Millstone Grits, until we reach the Coal Measures. Stanton and Harthill Moors are outliers of Kinder Scout Grit. On the opposite side of the Derwent valley the Chatsworth Grit forms the moors of Beeley, Darley, and Tansley. The Carboniferous Limestone outcrops again along the Ashover valley in an anticlinal bounded on the east by a downthrow fault, called the Trinity Chapel Fault, bringing the coal measures (See Fig. 3). The lead mines of Crich are in a dome-shaped inlier of limestone which is brought to the surface by two upcast faults.

The most productive part of the veins is generally found above the first toadstone. These toadstones are igneous flows truly contemporaneous with the limestone. That they are so is held on four grounds: (1) Though subject to great variation in thickness they are never seen to cut through the beds of limestone; (2) The underlying limestone and clay are altered while the beds above are not affected; (3) The upper surface of the toadstone shows steam cavities; (4) The character of a bedded ash assumed at Ashover, or the volcanic agglomerate with beds of dolerite at Hopton, are both inconsistent with an intrusive flow.

There are said to be three horizons in the limestone at which the toadstones occur, but the actual number of sheets or beds of toadstone is uncertain, for it is doubtful whether the so-called "clay joints" are not the decomposed fringes of a toadstone. As the upper portion of the toadstones have vesicular steam cavities filled with calcite, they present an amygdaloidal structure and being permeable to water often decompose into a greenish clay; the lower portion remains unaltered and is impermeable. At Black Hillock shaft on Tideswell Moor 100 fms. was sunk in toadstone without penetrating it, and it is supposed that this great thickness was due to the shaft being sunk upon one of the vents through which the igneous flow came.

Lead ore has been found in the second limestone under the toadstone, although rarely; at the Seven Rakes mine, Matlock, ore was even found in the toadstone itself. It is reasonable to suppose that these exceptional cases may coincide with a permeable condition of the toadstone. In 161 out of 180 observed cases the lode entirely disappeared in the toadstone (Phillips & Louis). The vein fissure is usually untraceable in the Yoredale shale and in the toadstone, but when it is a fault it may be followed through to the second limestone. A curious feature is the termination of some veins by another vein crossing them (see Fig.2), the latter probably being the older fissure.

One of the interesting features of Derbyshire mining are the drainage adits locally called "soughs." There were driven by the old men for the purpose of reducing the water level in the workings, and some of them are long and must have cost much money to drive. The principal soughs are:

Hillcar Sough, about four miles long, under Stanton Moor to Alport and Youlgreave (see Fig. 2). This dates from 1751 to 1789 and the cost has been variously estimated up to

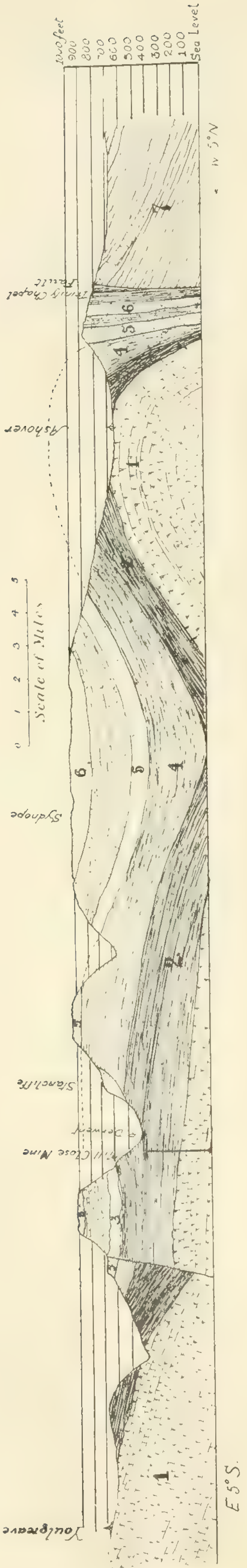


FIG. 3. GEOLOGICAL SECTION OF COUNTRY FROM YOULGREAVE TO ASHOVER.
(1) Carboniferous Limestone; (2) Yoredale Shales; (3) Shale Grit; (4) Shale; (5) Upper Kinder Scout Grit; (6) Chatsworth Grit (3, 4, 5, and 6 belonging to the Millstone Grit); (7) Lower Coal Measures.

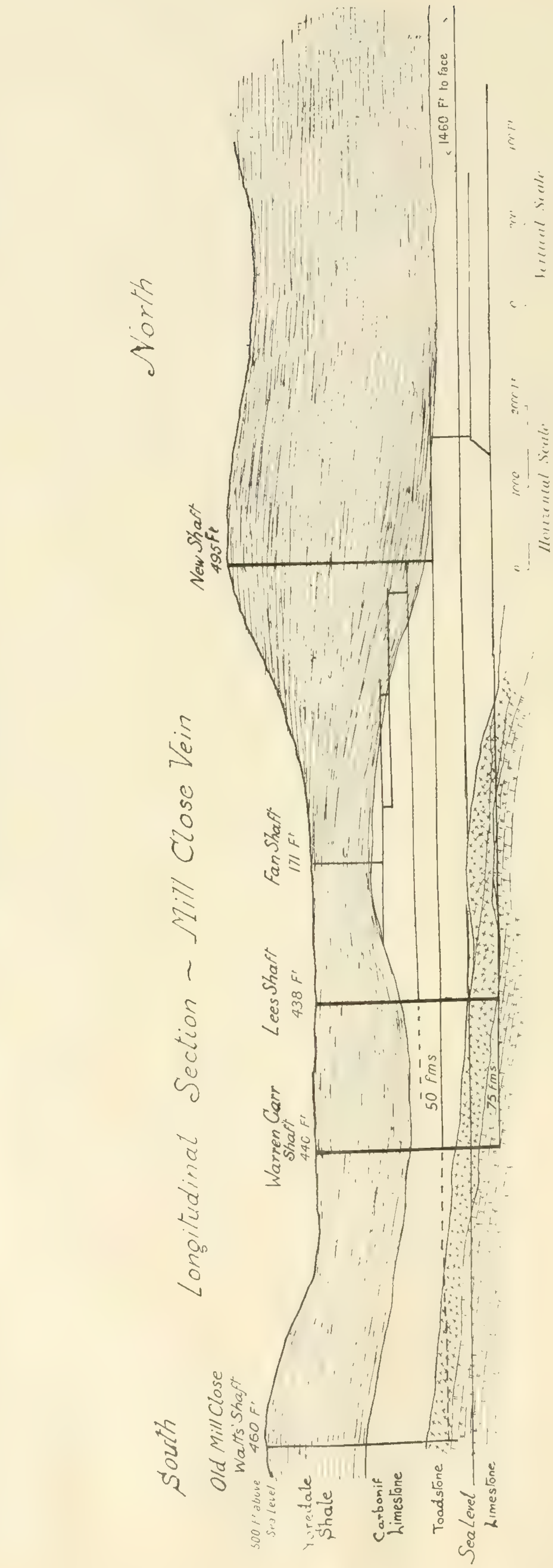


FIG. 4. LONGITUDINAL SECTION THROUGH MILL CLOSE VEIN.

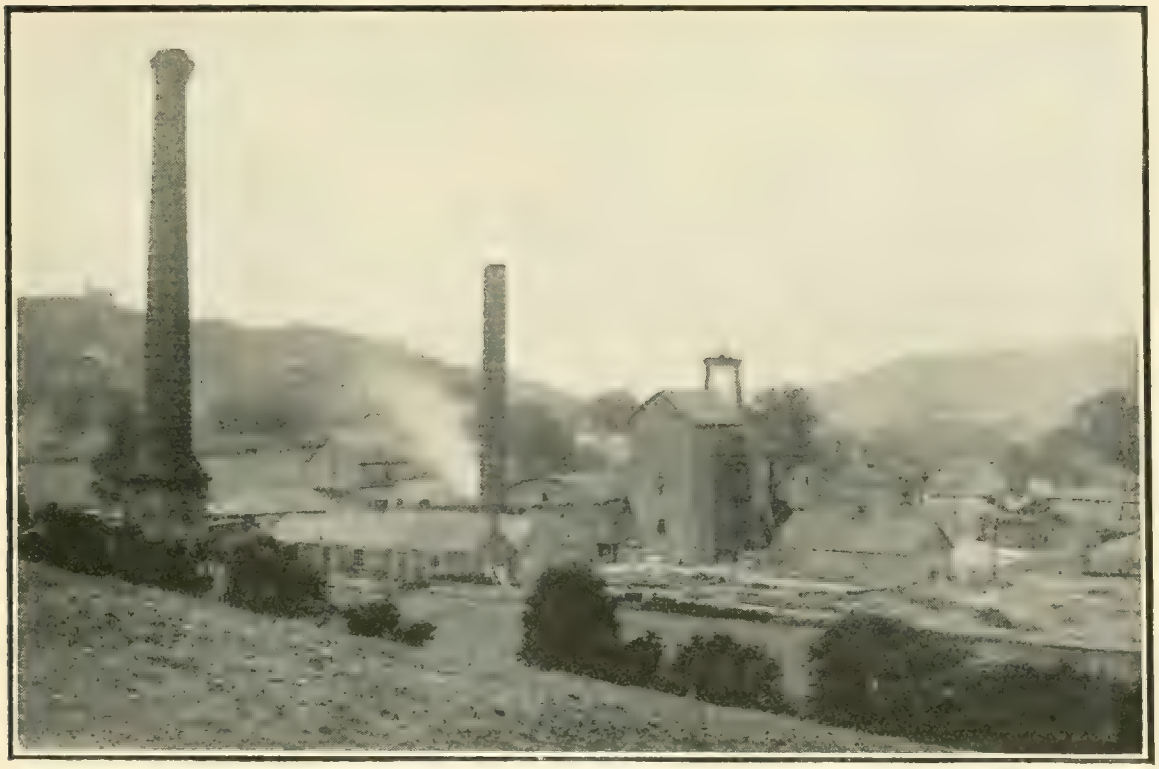


FIG. 5. VIEW OF MILL CLOSE MINE LOOKING NORTH FROM COWLEY KNOWL.

£50,000. It is interesting to note that the miners employed were paid from 8d. to 10d. per shift of six hours. The water discharged by this adit was measured in 1880 by Mr. Stokes and estimated at 15,000 gallons per minute.

Meerbrook Sough, $2\frac{1}{4}$ miles long, driven in 1773—1811, cost £45,000, and runs to Bole Hill and Wirksworth. It was taken over by the Ilkeston and Heanor Waterworks.

Yatestoop Sough, two miles long, begun probably in 1743, taking 21 years to drive at a cost of £30,000; runs to Winster and Elton (see Fig. 2).

Cromford Sough, between two and three miles long, cost over £30,000; driven about 1740, and drained the Gang mine at Wirksworth.

Stoke Sough, $1\frac{1}{2}$ miles, cost £35,000, runs to Edgeside and Ladywash mines at Eyam; driven 1730—1778.

Others are: Hannage Sough, $1\frac{1}{4}$ miles; Oxclose Sough, one mile; Magpie Sough, one mile (finished 1881), and Wakebridge Sough, one mile, which drains the Wakebridge mine at Crich.

THE MILL CLOSE mine, as worked by the "old men" on the south side of the Winster valley in the King's Field, was composed of a number of veins, sometimes parted, and usually about 140 yards in width. According to Mander's Miners' Glossary, 1824, "about the year 1743 the Quakers' Company, as it was then called, purchased the Mill Close mine in the Liberty of Wensley, upon which they not only erected a fire engine to draw water out of the mine but also built coes, smithies. . . . , they likewise wrought a sough or water gate (without having a vein) into Birchover Lordship and diverted a brook or watercourse down such for the purpose of turning a water wheel which they had in this said mine." From notes made by the late Mr. A. M. Alsop, the Quakers' Company is said to be probably the Old London Company (of Bristol), and the fire engine a 50 in. cylinder Boulton & Watt engine, erected on a shaft about 100 yards south of Watts shaft, now called Old Mill Close shaft. From data in his possession, the consumption of coal on a 24 hours' trial on May 1, 1759, was 4 tons 11 cwt. or 32 tons 4 cwt. per week, costing 12s. per ton. Assuming the consumption at 9 lb. per horse-power-hour the engine would be about 47 h.p. The date 1759 appears to be early for a Boulton & Watt engine, for Watt did not go to Soho Works, Birmingham, in partnership with Boulton until 1774. It is stated by Stokes in his paper already mentioned that the first steam engine in Derbyshire was erected in 1730 at the Yatestoop mine near Winster (see contour map) which was replaced by an atmospheric engine of 50 in. cylinder in 1780. The point regarding this engine is of interest, as it determines the period during which the mine was worked by the Quaker Company.

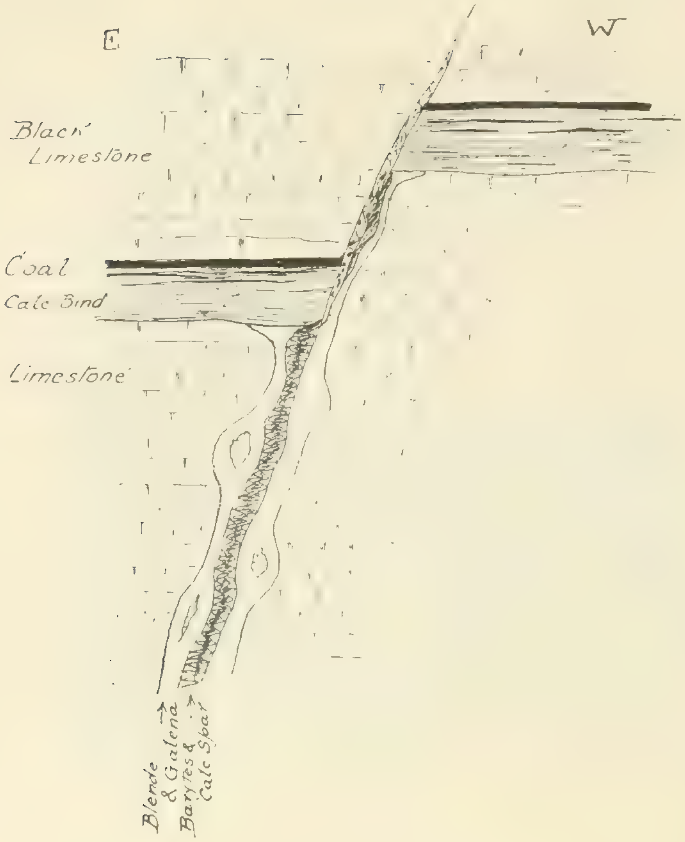


FIG. 5. LOCAL FAULT IN BLACK BED.

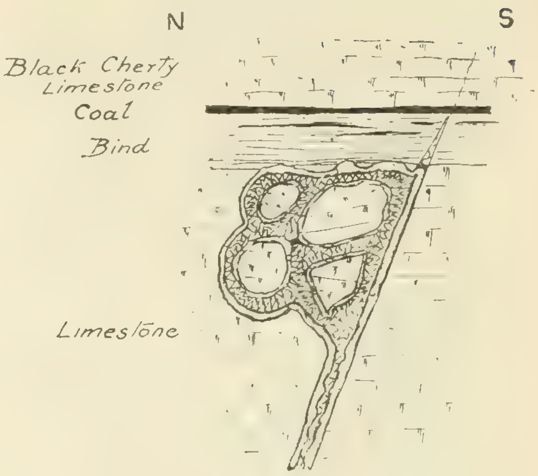


FIG. 6. BLACK BEDS, NO FAULT.

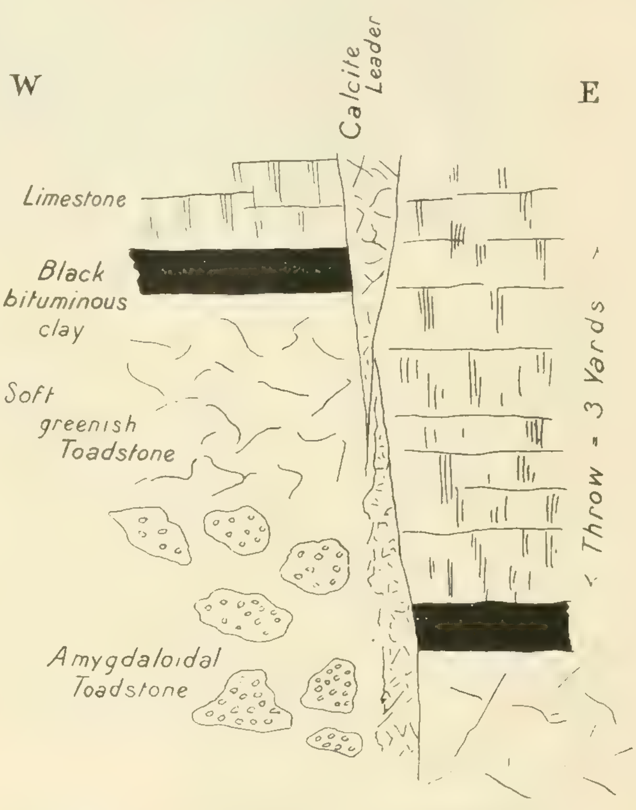


FIG. 7. FAULT AT OLD MILL CLOSE SHAFT.

The mine was re-opened by the late Mr. E. M. Wass in 1859 by sinking the Watts shaft on the south side of Cowley Knowl about 20 fathoms deeper, through the toadstone for about 6 ft. into the second limestone. A Cornish pumping plant by Thornewill & Warham, of Burton-on-Trent, was installed, with a 50 in. cylinder operating an 18 in. lift of pumps. When the workings were drained it was found that the usual tradition of rich ore having been left "in sight" was not verified.

The first measure of ore, about 25 tons, was recorded in 1861. The workings to the southward appear to have been disappointing, because the measures rising to the south brought the limestone to-day, and deposits so readily accessible were probably exhausted. A level was driven as far as the Winster road under the toadstone to test the lower limestone, but nothing of value was found. To the northward, however, the workings improved, and a new shaft at Warren Carr was sunk 580 yards north in 1873, and an 80 in. pumping engine by Harvey, of Hayle, and four Galloway boilers were in course of erection when the 50 in. engine at Watts shaft became unable to contend with the water. The mine was then drowned from 1875 to May 1877, and a breakage in putting down the 24 in. pitwork lengthened the stoppage. This was unfortunate, for lead was then worth £20 per ton. Cornish miners were engaged to recover the pumps and complete the installation.

Lees shaft was sunk in 1881, and is to-day the winding shaft, after being deepened to 73 fathoms in 1901. Ore dressing had been carried on up to this time by hand jigs and buddles. In 1883, an entirely new dressing plant was erected by the Sandycroft Foundry Company.

Mr. Wass died in 1886, and Mr. A. M. Alsop, the Barmaster for the Soke and Wapentake of Wirksworth, was entrusted by Mr. Wass' representatives with the general management, which position he continued to hold until his death in 1907. Mr. E. M. Wass was a representative of a Derbyshire lead-mining family, and was the proprietor of a large number of lead mines in the Low Peak district, none of which have been able to continue the struggle for existence to the present time, with the exception of Mill Close. Mr. Wass' father had developed with great success the famous Wakebridge mine, in the mineral liberty of Crich.

Looking at the longitudinal section of Mill Close, we notice the measures dipping to the north, the limestone underlain by a sheet of impervious toadstone. These conditions would tend to drown the workings extending northward because the water could not drain back to the old shaft unless long unproductive drainage levels were driven under the toadstone. Fortunately the surface permitted the sinking of fresh shafts and transference of the pumps to them. In 1887 the flow of water was estimated at 1,000 gallons per minute, and an 18 in. plunger was added to the 80 in. engine at Warren Carr; while in 1889 a new shaft was sunk to 50 fathoms and equipped with a 60 in. engine brought from Wakebridge mine in 1891, the old engine, 50 in., being transferred from Old Mill Close and started in 1896–7. The 80 in. engine in its day was the largest and most efficient engine in Derbyshire. It was fitted with its present piston in 1898 and with Hathorn-Davey differential gear in 1890, these being the only considerable items in the forty years it has worked.

Fig. 8. Headgear at Lees Shaft.

The position of Mill Close, and its relation to the surrounding mining districts, is shown on the contour map, together with a rough indication of the chief vein systems. The ore mined is dressed to 82% lead and carted to Lea Lead Works, about eight miles away, at Lea Bridge to the southeast of Matlock, to be smelted into pig. The pig lead is practically free from silver and for this reason is peculiarly suited to the manufacture of white lead.

The mineralogical features of the deposit are well described by Mr. Cyril E. Parsons in the volume of Transactions of the Federated Institute of Mining Engineers, 1896–7, although some features prominent then, such as the abundance of iron pyrites, are not true to-day. The banded structure with the blende next the limestone, then galena, then fluor, then earthy barytes and calcite, is still characteristic. When the ore penetrates between the beds of limestone as a flatting, it usually consists of pure massive galena in direct contact with the limestone; in wider caverns or extensions of the vein filled with with disseminated rosin blende seems to be typical of this part of the county. This blende is of better quality than the more ferruginous blende associated with galena.

The most interesting feature about the deposit at Mill Close is the influence of the so-called "Black Beds" which are found 36 ft. below the contact of the Carboniferous Limestone with the Yoredale Shale. Two sketches (Figs. 5 & 6) show the effect on the vein at working places; one a simple capping of the vein and flatting,

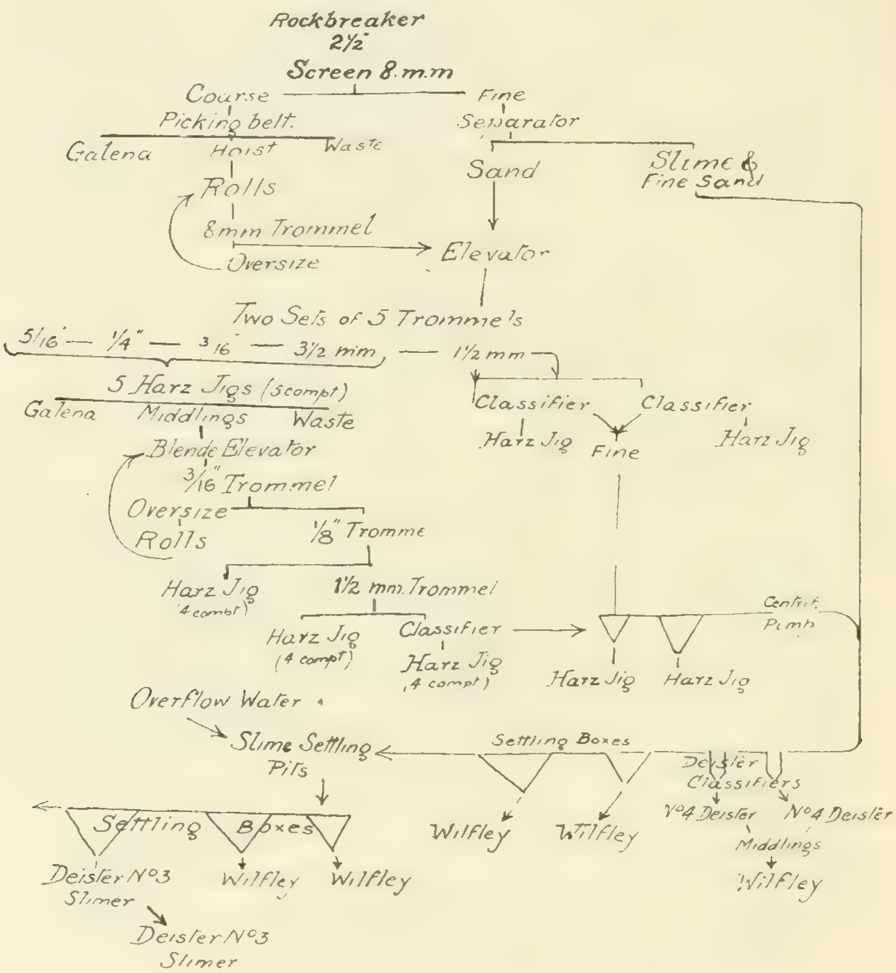


FIG. 9. FLOW-SHEET OF MILL CLOSE DRESSING PLANT.

broken blocks of limestone and dogtooth spar, the galena and blende lining the sides are separated from the limestone by a microcrystalline sandy calcite, called locally a "sandy back." Usually the harder limestone favours the occurrence of blende, while pink barytes (wheatstone or kevel) and fluor-spar are signs of poverty in lead. The fault on the Main Rake at Old Mill Close shaft, illustrated in the "Geological Memoirs of North Derbyshire," from which the sketch (Fig. 7) is taken, does not persist northward. The termination of the Rake in depth in barren calcite or calcite the other showing conditions when these beds are faulted. In the latter case the crushed material shows galena and bright coal intimately mixed in contact with the vein, the coal being quite unaltered. A somewhat similar case at Shilbottle Colliery is quoted by Phillips and Louis (p. 184), though here, in our case, the coal is the stranger. In some cases the ore-bearing vein passes through the black beds from below, the deposit widening out in the softer beds of limestone and running right up to the shale. Gas is troublesome in the neighbourhood of the black beds, and also when caverns that have drained fill up with gas. An explosion occurred in November 1887, since when extra ventilation has been supplied and the mine put under the Special Rules.

The ore-dressing plant has been considerably altered and extended since 1883. The flow-sheet (Fig. 9) shows the ordinary dressing practice. The speed of the jigs is high, being 180 strokes per minute on the coarse jig treating $\frac{5}{16}$ in. material. Experiments conducted on the slime material with a view to flotation treatment show that the oxidation of the fine particles of galena is so rapid that only fresh material can be satisfactorily treated. Wilfley tables were first installed in 1899, the older ones being replaced by Deisters in 1914.

The chief item in the power plant is the pumping. The distribution is as follows in brake-horse-power-hours per week:

Pumping	55,440
Dressing	4,020
Compressor...............	2,700
Miscellaneous	3,216

The 80 in. and 50 in. Cornish pumps are continuously at work raising 1,800 gallons per minute. The 80 in. raises water from the 73 fm. level, partly to surface, and partly to overflow along the 50 fm. level to the 50 in. engine, which pumps to surface and to the Yatestoop Drainage Adit. With the 50 in. there is the 60 in. as a standby from the 50 fm. level, while to raise the water from the 73 fm. to these two acting as duplicates, there is a Mather & Platt centrifugal, driven by a three-phase motor installed at Lees shaft. The three-phase current is generated by a Belliss Morcom-Westinghouse set of 150 kilowatt capacity. The boilers are fed with the hot water from the condensers of the pumping engines pumped through a Green's economizer. Coal slack is brought by the aerial rope-way and fed under the boilers by mechanical stokers.

The lead ore was originally smelted in Derbyshire on hill tops by means of wood fires kindled on mounds of stone, or in trenches in the ground usually cut in a westerly direction to catch the prevailing winds. These hills were called "bole hills" and are widely distributed. Reverberatory furnaces appear to have succeeded these primitive methods, and in 1698 the cupola was introduced from Holywell, North Wales, in order to treat the slags and poorer ores. In the earlier times, the land being uncultivated until the destruction of timber, the question of "smoke farming" did not worry the metallurgist; but ultimately he had to do something, for in 1777, chambers for the collection of fume were first erected at Middleton Dale. Stokes shows three cupolas in work at Bradwell, Alport, and Lea about 1881.

The plant at Lea Lead Works consists of four Scotch hearths and two reverberatories. A large brick condensing chamber arrests the major part of the fume, and is followed by 600 yards of spiral flue and a short stack. The raw ore smelted on the Scotch hearths is mixed with burnt fume from the first condensing chamber. The reaction of oxide and sulphate with excess of raw ore obviates the necessity of roasting. In these days of dear coal, even in the colliery districts, the Scotch hearth requiring less than 20% by weight of fuel, including power, to ore smelted, compares usefully with the reverberatory consuming 50% of best coal to the ton of ore smelted. The recovery in pig is about 86% on the Scotch hearth as compared with 84% in the reverberatory, though the latter smelts fume, slime, and similar unfavourable material. A Spanish slag cupola was used at one time to run the slags down, but now the quantity is not sufficient and the slags produced are sold.

So far as one can ascertain the lead ore remaining in Derbyshire extends laterally under the shale and grit in the upper beds of the limestone; the productivity of the veins is as irregular as usual, but there is no reason to expect it to be diminished. The small "poor man's mines" worked under the old customs could only exist in the districts where the limestone outcrops, and it would be impossible for them to follow the dip of the measures without being drowned out. The old drainage adits which cost so much money are now of little use except to provide a free water way for new pumps. The prospecting of the measures under the shale and grit would require a heavy capital outlay, and in order to attract capital the royalties would have to be lowered for the lead so obtained, and some inducement held out by the State to foster the industry. It is faulty logic to assume that because charity begins at home every home industry has the taint, and if the War does "reorganize the world" let us hope that we in this country will begin at home.

I am indebted to Major Denman for permission to use records and for historical data, and also to Mr. S. Petts and Mr. D. Morgan for information about the old mine and the loan of photographs.

ORE TREATMENT AT THE PERSEVERANCE MINE,

KALGOORLIE, WEST AUSTRALIA.

By the late W. R. CLOUTMAN, A.R.S.M.

This article, the first section of which appears in this issue, is one of a series of papers written by the author on the geology and mining and metallurgical practice at the Great Boulder Perseverance, under circumstances detailed in our Editorial columns.

THIS paper gives particulars of metallurgical practice at the Great Boulder Perseverance gold mine, at Kalgoorlie, West Australia. The course of the ore is traced through jaw breakers, ball-mills, roasting furnaces, Wheeler pans, tube-mills, agitator vats, and filter presses, and particulars are given of the clarifiers, zinc-boxes, the treatment of the precipitate, with notes on recoveries, and assays of ore, solutions, residues, etc.

The geology and the ores of Kalgoorlie are sufficiently well known and need not be discussed here. The ore now treated at the Perseverance is of low grade. The gold is associated with pyrite and there is little free gold, telluride, or arsenical pyrite. The constitution of the ore sent to the mill is indicated by the following analysis of a mixture of samples taken three times daily over a period of six weeks:

		%
Insoluble	SiO_2	46·58
	Al_2O_3	11·51
	FeO	1·60
	MnO	0.20
	CaO	0·20
	MgO	0·29
	Alkali and loss	3·08
Soluble	FeS_2	6·80
	Fe_3O_4	4·38
	$CaCO_3$	13·42
	$MgCO_3$	6·93
	Al_2O_3	2·06
	K_2O	0·87
	Na_2O	0·37
	Loss and water	1·71
	Total	100·00

The ore is about equally schistose and granular. The analysis shows that it is extensively carbonated, and it may be inferred that some of the iron also exists as carbonate.

OUTLINE OF PRACTICE. — The mill is essentially an all-roasting and all-sliming one. As all the ore must be roasted, the crushing is done dry; the crushing plant consists of a battery of ball-mills. The crushed ore is roasted in 6 Edwards "Duplex" furnaces, and, after the addition of cyanide solution, passes to the fine-grinding plant, consisting of Wheeler pans and tube-mills, and thence to the slime-agitation vats. After two hours agitation with a weak cyanide solution (0·09%), the pulp is run off and filter-pressed in presses of the Dehne type, residues trammed to dump, and gold solutions sent to zinc-boxes.

An actual extraction averaging 90% is obtained. The average value of the raw ore is 5 dwt. gold per ton. The average monthly tonnage is about 21,000 tons. The treatment cost per ton in 1912 was 9s. 9·4d.

The sulphur in the ore is only about 3%, but it requires to be roasted off to get a good gold extraction. Inferior roasting gives rise to soluble sulphides, which interfere with precipitation in the zinc-boxes, also to calcium sulphate, which also causes trouble with the precipitation.

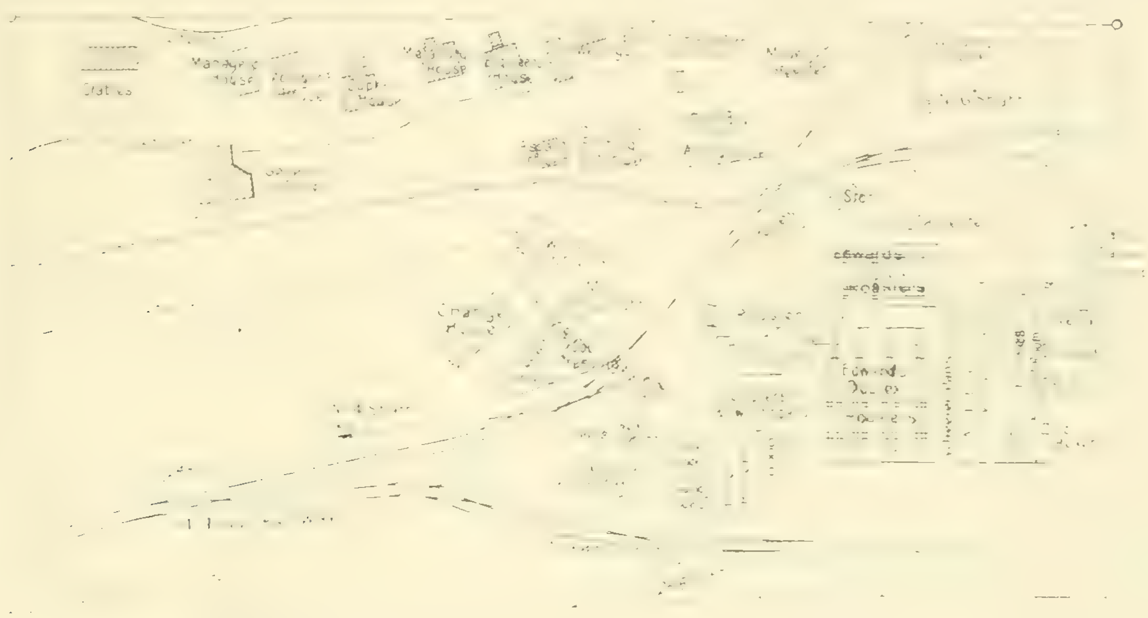
Sliming of the ore is not so thorough with the present ball-mills as with the Griffin mills used before the fire in 1909. At present 50% of ball-mill product is minus 150 mesh, and, after going through the pans and tube-mills, 70% will pass 150. The average value of the residues over the period 1909-1913 was 14½ grains. The power used is electrical, and is purchased from a power company.

HADFIELD JAW BREAKER.—The ore hauled from the main shaft is, in the ordinary way, tipped direct into the rough ore bin, which forms the supply for the breaker. If the breaker is not in use, there is an alternative course; the ore may be trucked over the top of the rough ore bin, and over an overhead tramway a distance of 110 ft., and then put through a No. 5 Gates crusher. The ore in that case falls on a grizzly, the fines going direct to two No. 3 Gates, immediately below.

The rough ore bin has a sheet steel bottom, sloping at an angle of 45°. The front of the bin is built of timber on the outside, then steel plates, then close horizontal rows of 4 in. iron pipes, which take the wear due to the falling ore. The pipes are kept in position by 4 vertical pipes, bolted through to the timbers. The feed to the breaker is through a single door, at the bottom of the front side of the bin, which leads to a chute. This mouth is closed by two steel doors, one behind the other, and working in slides, controlled by levers attached to them. The bin is never emptied so much that the doors shall be exposed to the full force of ore tipped from the skips above. The bin holds 365 tons. Steam jets can be turned on, to play on the ore as it falls into the bin; this greatly helps in laying the dust.

When working the breaker, the door above the chute above mentioned is pulled right up, and the flow of ore is controlled by the lower door. The chute and the mouth of the breaker are kept full. In working the breaker, the main point to be attended to, in order to keep the flow of ore continuous, is to keep the corners just inside the doors clear. The bottom of the chute consists of a grizzly, 3 ft. long. Through it fines can fall straight on to the Robins conveyor-belt on to which the breaker delivers. When the breaker is not in use, the two doors of the chute are let down, and a couple of bars, with a sheet of steel over them, are laid over the breaker mouth, to prevent possible choking of the latter.

The Hadfield breaker has a mouth opening of 30 by 18 in., and a capacity of 1,000 tons per 24 hours. The jaws are set to break to 6 in. The breaker is driven by a 47·5 hp. A.E.G. motor which takes on the average from 40 to 45 amperes, but the current may momentarily go up to 120 amperes. Should it exceed the latter figure, the main circuit breaker comes out on the switchboard in the engine house, if the fuses on the motor board have not already gone. Trouble from this source is not frequent, as nothing short of a spalling hammer head is likely to hold the breaker up. There is no breaking point on the breaker. Excessive stresses may fracture the pitman. The pitman is kept cool by constant lubrication and water jets, only; there are 4 grease cups to the pitman journals, which are filled up three or four times a shift, the lubricant used being a good quality compound grease, and the cup covers are given turns at frequent intervals during running. Jets of water play on the outside of the pitman. The three bearings to the flywheel and driving pulley shaft have two oil lubricators each, and cylinder oil is used. They give a constant drip, and are supplied from an overhead storage tank, which saves frequent filling up by hand. If the bearings of the shaft or pitman are allowed to get hot, the white metal soon runs out. The renewing of the bearings is a heavy and a long job. It is done about every 6 weeks, the wear on them being considerable.



Surface Plan of the Great Boulder Perseverance.

The feed to the bin cannot keep pace with the breaker, when it is working. Consequently half an hour is allowed at change of shift and half an hour at crib time, during which the breaker is idle, so that a full day's work for the breaker would be 21 hours. It needs one man to attend to it, every shift. It actually runs on the average 13·2 hours per day of 24 hours.

Gates Crushers.—From the breaker an inclined belt-conveyor, which is set at about 35°, takes the broken ore to the two No. 3 Gates crushers. The belt of the conveyor is 18 in. wide; it is of the Robins make, and has a life of about 15 months. The idlers on the top side are placed so as to make the belt trough-shaped. Wood planking up the sides prevents ore falling off the belt. The idlers on the lower side are in line, so that the belt runs flat. The belt passes over a tightening pulley, to which is hung a heavy weight, in order to keep the belt taut. If the Gates crushers should become choked, the ore tends to pile up at the discharge end on the belt. The belt travelling under this pile of ore gets damaged. To prevent this a bell communicates from the crushers to the breaker, so that feed on to the belt may be stopped quickly if necessary.

The Gates crushers are set to deliver a product not larger than 4 inches. They have breaking points made of 6 in. lengths of 1 in. gas pipe, which act as pins joining the shaft pulleys together, and which give way under excessive stresses, to prevent damage to the crushers themselves.

The Hadfield breaker is driven at 230 r.p.m.; the Gates (No. 3) crushers at 450 r.p.m. The capacity of each of the latter is 500 tons. The Gates (No. 5) crushers are driven at 372 r.p.m.

The ore from the Gates crushers is delivered into the crushed ore bin of 1,000 tons capacity, and is taken from the latter to the ball-mill ore bin by an inclined belt-conveyor, 14 in. wide. At the head of this conveyor there is a tripper, which either deflects the stream of ore over a steel lip into that end of the bin, or returns it to the tripper belt, after the belt has passed round two pulleys, and is running horizontal, to be fed into the far end of the bin. The tripper is movable, so that ore can be delivered to all parts of the bin. The far end of this bin is served by ore dropping straight off the end of the conveyor, or an extension top can be used to guide the stream still further toward the end of the bin.

The ball-mill bin, of 960 tons capacity, is lined with steel sheets. The bottom of the bin is inverted V-shape, so that ore feeds readily to the ball-mill chutes.

BALL-MILLS.—The ore broken by the Gates crushers is fine crushed by a battery of 8 No. 8 Krupp ball-mills, each having a capacity of 100 tons per 24 hours. These mills are placed in pairs, 2 pairs on each side of the ball-mill house, with the bin in the space between them and above their level, and the driving motors also between them, but on the ground floor. These motors are A.E.G. make, one to each mill; 75 hp., 73 amperes, 550 volts (stator), 215 volts (rotor), 385 r.p.m. The mills are about 9 ft. in diam. and 4 ft. wide. In normal working they take from 55 to 60 hp. each.

The feed to the mills is from a suspended tray, of the bumping type. The mill with its spur wheel is on a counter-shaft, and is driven by the motor through a belt drive and pinion engaging with the spur wheel. The mills are run at 24 r.p.m. The gear ratio of spur to pinion wheel is $5\frac{1}{3}$, and the gear ratio of ball-mill pulley to motor pulley is 3. The speed recommended by makers is 22 r.p.m. Ore passing through the ball-mill screens falls through a hopper on to a push conveyor below, by which it is taken to a bucket elevator and distributed to the roasters by another push conveyor. The ball-mills started work on August 1, 1910.

The balls at present in use are of steel and obtained from Armstrongs. They are $4\frac{1}{2}$ in. in diameter and 18 lb. in weight. The total weight of balls which it has been found best to carry in each mill is 4,400 lb. To keep up this weight and to compensate for wear, 3 new balls are added after each 24 hours' run of the mill. As the proper compensation should be 50 lb. for each 24 hours, and 3 balls weigh 54 lb., only 2 balls are added every fourth such period. The balls are of forged steel, hydraulically pressed.

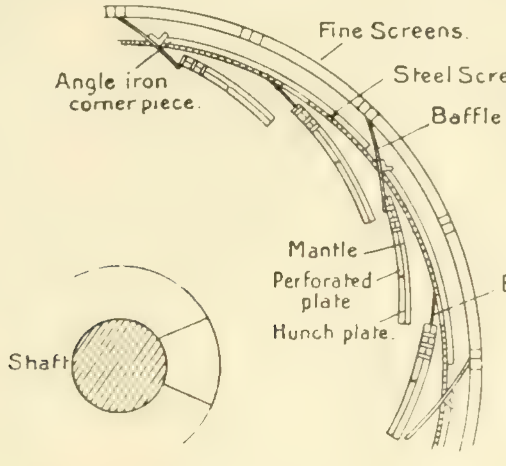
Every time the mill is stopped for examination of the inside plates, re-lining, etc., the small balls are picked out and rejected, and nothing less than 2 in. in diameter is returned to the mill. Krupps recommend a minimum of 3 in. When the mill is emptied for re-lining, the charge of balls is weighed, small ones are picked out, and the correct weight of about 2 tons is returned. These rejected balls are included in the consumption of balls.

Balls from various makers have been tested with the following results:

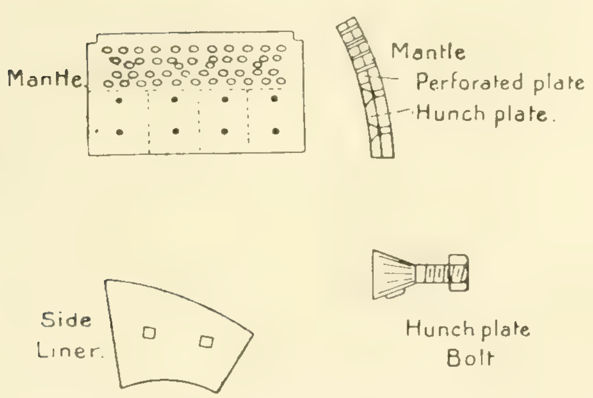
Maker	Consumption in lb. per 24 hours.
Armstrong	53·4
Cammell Laird	56·8
Fried. Krupp	63·5

In point of cost, Armstrong balls are 25% cheaper than Krupps. The average monthly consumption is 10,500 lb., equivalent to about 0·5 lb. per ton milled.

The ball-mills are carried by heavy shafts, running through their centre and supported on bearings outside. The sides are formed of circular plates, with liners bolted on the inside. There is also a man-hole on the driving side. The circumference of the mill is formed by a succession of screens and plates. On the outside are fine wire screens in 12 sections on wooden frames. These screens are of course continuous all the way round. The screens next inside are called steel screens and are made of punched steel plates, 6 sections altogether, and with a gap of 2 in. between each section. Inside these are the perforated plates, thick steel plates with $\frac{3}{4}$ in. holes, and the steel hunch plates in sets of 4, which are bolted on the inside of the mantles or bearing plates. There are 12 mantles placed radially in each mill, with step gaps of about 2 in. between each other. They are separated at the periphery



Cross Section through Ball Mill



SKETCHES OF DETAILS OF THE BALL-MILL
Mantle plates are fixed members of mill; hunch and perforated plates are renewable.

by baffle-plates, which extend past the perforated steel screens. The relation of these screens and plates is shown in the sketch. The outer half of the mantle is perforated by taper holes with an outside diameter of 1 in., and an inside one of $\frac{3}{4}$ in. There are 4 rows of these holes, 15 holes in each row. The mantle is held in position by bolts passing through the side plates and its up-turned ends. The perforated plates on the inside of the mantle have holes corresponding in position with those in the mantle. There are two of these plates to each mantle. They and the hunch plates are bolted to the mantle with conical headed bolts, which draw the two tightly together. The bolts are prevented from turning by a projecting lug in the conical head, which fits into a slot in the bolt hole through the plate. When the nuts are tight on they are prevented from working loose by jamming them on to the nuts with the aid of a cold chisel. To remove them, the nuts must be cut off. The hunch plates take all the wear of the falling balls and ore. When worn down, they are turned, and used until the edge is down to $\frac{3}{16}$ in., the outside edge naturally getting most of the wear. When mills are re-lined, all the perforated and hunch plates are renewed. The best of the second-hand plates were used later on when renewing single plates in mills but are now discarded. The middle hunch plates naturally wear quickest. Mills are re-lined once in six to nine months.

The steel screens are made so as to cover two mantles. A strip about six inches wide along their centre line is not perforated. Small stuff finding its way past the baffle plates can pass this screen without going through the perforated plates. If fine enough to get on to the screen but not to pass through it, it is returned to the inside of the mill, through the space between screen and baffle plate. The holes in the steel screens are $\frac{1}{4}$ in. diameter.

The outside sets of screens is in 8 sections, each screen having 6 panels. The frame is of wood, bound with iron. The screens are of Greening's woven wire, 28 mesh, with 784 holes per sq. in., the wire approximately 30 s.w.g., size 4 ft. 3 in. by 2 ft. 3 in., $9\frac{1}{2}$ sq. ft. Coarser screens have been tried, but with the effect of over-taxing the pans and tube-mills. Screens of 900 holes per sq. in. have been tried, but although the results were good, the tonnage put through fell off to too great an extent. With the screens at present in use, about 50% of the product will pass through a 150 mesh.

The gap between mantles, steel screens, and baffle plates allows material to gain access straight away to the fine wire screen. This was at one time prevented by covering the open slot with a plate with $\frac{3}{4}$ in. holes. These have been discarded as an increased tonnage is thereby obtained, though at the same time, the wear on the screens is greater. Strips of baize are glued to the sides of the screen frames, so that a tight joint is made. The screens are held to the mill frame by $\frac{3}{8}$ in. bolts, made T-shape from ordinary hexagonal heads to prevent turning, and to each other by $\frac{1}{4}$ in. bolts, two on each side.

Two or three mills are stopped and examined every shift, the screen being brushed with wire brushes, and taken out and replaced if damaged. The product from each mill is also examined at intervals, in order to detect and remedy serious damage to the screens.

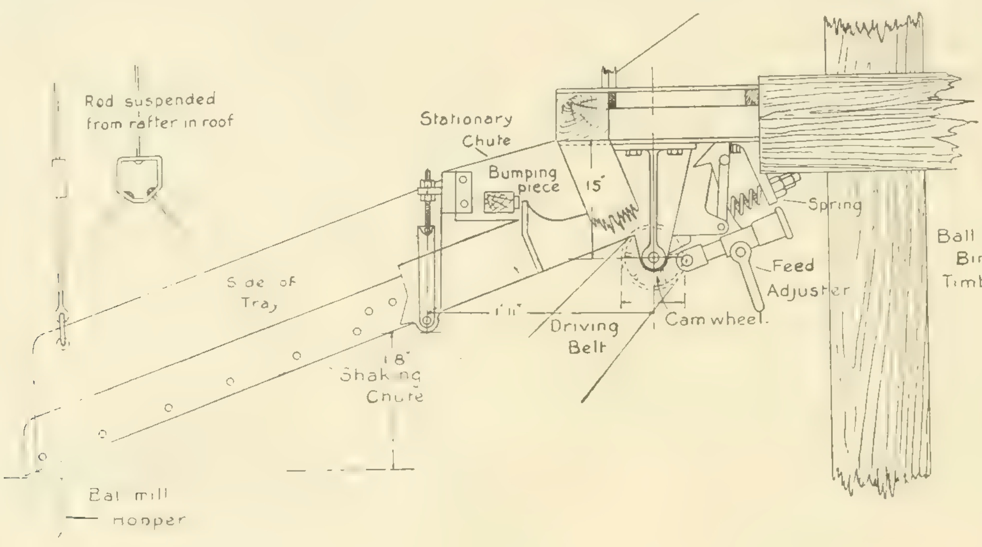
Mantles receive very little wear; the original ones were in use in 1913. The lifes of other parts are: Outer circle liners: Hadfield 187·5 days, Krupp 76·9 days; Inner circle liners: Hadfield 322·4 days, Krupp 123·9 days. The liners on the feed side wear faster than those on the driving side, the average life of the former being 240 days of 24 hours, and of the latter 360 days. These liners, as also the perforated and hunch plates, are of manganese steel, and are obtained from Hadfields. The extended wear of these plates more than compensates for the extra cost over those supplied by Krupps. An attempt was made to make perforated plates and hunch plates at the mine foundry, but the material produced was only a hard cast iron, which was unable to stand the heavy wear required of it.

The life of the hunch plates was: Hadfield 113·5 days, Krupp 69 days; the life of the balls was: Armstrong, 53·4 lb. per 24 hrs. This consumption includes the weight of rejected balls under 2 in.; neglecting these the consumption would be about 50 lb. per 24 hrs.

As regards the life of the screens, the total monthly consumption is 1,628 sq. ft.; being 1,372 sq. ft. new screen and 256 sq. ft. "repaired," a "repaired screen" being counted as ¼ the area of a new screen.

The ball-mill chutes are suspended and of the bumping type. A stationary chute leads from the bin to a tray, supported at that end by arms whose lower ends can move with the tray; at the other end the tray is suspended from a beam 15 ft. or so higher up by a long rod. Just beneath the chute is a small cam wheel, driven from a pulley on the mill axle. The cam wheel strikes a roller which forms part of the chute, and, in striking it, causes the chute to move backward. The extent of this motion is controlled by a regulator, as it affects the feed of ore to the mill directly. A spring at the rear of the chute is compressed when the chute moves backward, and when released, causes the chute to travel forward, the movement being checked by a fixed bumping piece. The ore travels down the chute in a series of small jerks. The metal trough in which the ore lies has sides about 1 ft. high. The angle at which the tray rests can be altered by bolts connecting it to the stationary chute, and by screwing the long rod in the front up or down in its stirrup.

These chutes used to have perforated bottoms, so that fines were taken to the conveyor below the mills, without passing through the latter. These perforated bottoms have been discarded, as they tend to choke up and obstruct the flow of ore over them. The mouth of the stationary chutes is rather small, so that coarse ore tends to block up the opening. With such ore, a bigger shake is necessary for the same feed than with finer ore.



FEEDER FOR THE BALL-MILLS.

The range of feed varies with different sized feeds, but is in most cases about one turn of the regulating wheel. Since the nature of the ore fed to the mill is constantly altering, the feed, determined by the degree of shake given to the chutes, also requires frequent alteration.

Any wood with the ore or charcoal in the concentrate returned to the mill are picked out as the ore travels down the feed chutes. A feed hopper leads the ore to the centre of the mill, the axle passing through it, and being protected from the falling ore by a plate fixed over it.

The regulation of feed to the mills, and the state of the mills at any moment, is determined by the sound they make. By listening at the feed hopper, it is possible to tell whether the mill is running light or heavy, and whether its charge of balls is too great or too small. Ammeters are also installed, one to each mill motor, which are fixed by the feed chutes. These afford a rough indication of the state of the mill. An empty mill, that is empty of ore, takes about 40 amperes, while one well loaded with ore usually takes from 55 to 60 amperes, but these variations naturally do not clearly distinguish between different classes of feed, so that the mills cannot be run solely on these indications.

When a mill is running properly, it gives out a dull grinding sound, and balls and coarse ore can be heard falling off the hunch-plates every instant. When the mill is light, the dull grinding sound gives place to a more defined rattling of balls against each other. If the mill is too full, the only sound that can be distinguished is a deep muffled one, due to the fact that the material inside the mill is not being carried over and falling back on itself, but remains almost stationary, with not much grinding going on. At intervals balls, etc., may be carried over and in falling tend to strike the shaft, this sound being occasionally heard above the muffled one.

If mills are allowed to get light, there is an increased risk of damage to the screens of the exits. It is preferable to let a mill run light than allow it to become heavy. In an aggravated case of the latter kind, it may be necessary to stop the mill and dig it out, since no grinding will go on in a very full mill.

If the feed is variable, it is better to risk damage to screens, and unnecessary wear on balls and liners, than to overfill the mill. That is to say, it is better to give it a light feed and keep on the safe side.

Wet ore and concentrates of a damp nature tend to make a mill sweat, that is, it will steam inside, and the condensed moisture can be seen on the inside of feed hopper. Should a mill start sweating, the feed must at once be cut off, and the mill run down till it is again dry. There is otherwise danger of the damp fines inside caking on plates and screens. This trouble is naturally more likely to occur in winter than in summer, for the higher temperature will prevent so much steam condensing. The flues leading to the dust arresters are also liable to choke up, unless they are highly inclined, when the mill sweats. They must be cleaned out once or twice a year.

A dust flue runs diagonally up both sides of the ball-mill bin and is connected to the mills with smaller steep flues. The main flues convey dust through two Sturtevant fans to cyclone dust-arresters. There are two of the latter to each fan. The dust passes from one to the other, and any deposited dust passes from the point of the cone-shaped arrester to the push conveyors. From the second arrester the flue leads to the main brick flue in connection with the roasting furnaces.

The dust flues are cleared as far as possible every morning, and once or twice during the winter to prevent possibility of their becoming choked when mills sweat.

The draught caused by the fans keeps the mills cool. As soon as it is stopped, the mills begin to sweat, even when grinding ordinary dry ore.

THE ROASTING FURNACE CONVEYORS.—The push conveyor beneath the ball-mill hoppers takes the ore to a cross push, and this in turn to a belt bucket elevator. From the elevator, the ore is fed to the furnaces from push conveyors. The general construction of these conveyors is shown in the sketch. There is a main frame actuated to and fro by a crank and connecting rod. To the frame are fixed a number of cross bars, about 6 in. apart, and from alternate ones hang the blades. These blades are free to swing forward when the conveyor moves backward. But on the forward stroke they are prevented from swinging backward by two short arms which catch under one of the cross bars. The blade therefore remains vertical and pushes the ore forward, and then swings up and slides back over the ore on the back stroke. They are steadied by the middle arm.

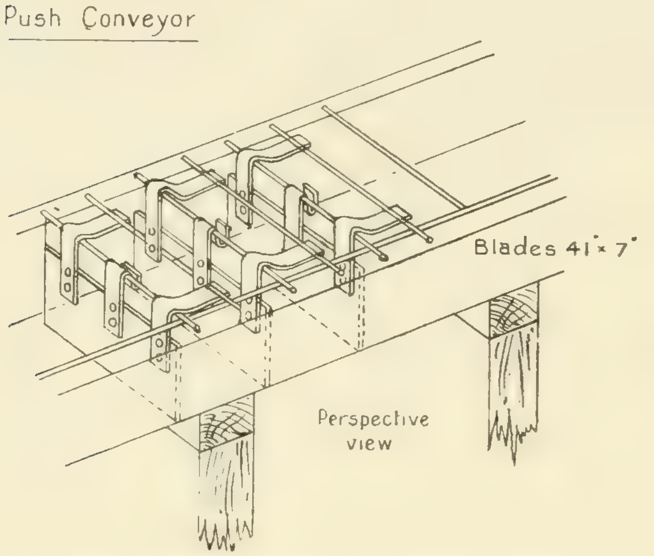
The frame is supported at intervals of about 12 ft. by ball bearings; 16 lb. balls, $4\frac{1}{2}$ in. diameter, such as used in the ball-mills, are held in a bearing about 1 ft. long. This form of bearing has proved efficient and reliable. The sides of the trough in which the push works are made of wood, the bottom of sheet iron.

The cross push feeding furnaces No. 5 & 6 receives its feed from the main conveyor. It has a small return push which forms part of it, and is half the size of the forward push. The blades of the return push are hung on the opposite side of the cross bars to the forward pushes. An inclined side at the end of the conveyor leads any excess of ore to the return push.

The roaster hoppers communicate with the conveyor by circular ducts opening into the bottom of the push trough. These openings, in the case of the main cross push, extend over both forward and return troughs, so that returned ore is distributed to the hoppers that need it.

The bearings on this conveyor, feeding furnaces 5 & 6, consist of rectangular frames resting on a couple of small wheels joined by an axle. The wheels run on rails to and fro.

The connecting rod actuates the push frame through a small carriage fixed to the frame,



PUSH CONVEYOR FOR THE ROASTING FURNACE.
On forward stroke.

on which the cross-head bearings are bolted. This carriage should be low if the power is to be exerted nearly in line with the push frame. To the carriage is also fixed a wire rope, which passes out to a counterweight, which assists the crank over the dead centre.

At the head of the main push, samples are taken of raw crushed ore of ascertaining raw-ore values. The sampling is done automatically by three short pieces of gas piping, set vertically in the push trough. They have slots through which a small proportion of the ore stream constantly falls. The three pipes are set so that each takes a sample from one-third of the whole stream, continuously. The middle pipe takes a larger sample than the others. The sample is automatically cut down four or five times by deflectors which split the stream. These samples are removed every shift and are mixed and cut down in the assay office, giving three final samples, one for each automatic sampler.

The push conveyors have proved economical, they work well, and give very little trouble. They compare very favourably with the screw and belt conveyors in use in the old mill. By having the main push in two halves separate, and worked by two cranks on the same shaft, the load would be more nearly equalized and constant.

The two conveyors beneath the ball-mills have blades 19 by 7 in., stroke 18 in., and work 24 strokes per minute. Between them and the cross push are two pulp bins, each of 68 tons capacity. In the event of the cross push breaking down, there are two screw conveyors 12 in. diameter to take the ore to elevators. The main push feeding the roasters has blades 41 by 7 in., 18 in. stroke, and 22 strokes per minute.

(To be continued)

Canadian Mineral Yield 1916.

Metallic:	
Antimony ore (exports), tons....	794
Cobalt metallic and contained in oxide, etc., lb.	841,859
Copper, lb.	119,770,814
Gold, oz.	926,963
Iron pig from Canadian ore, tons	115,691
Iron, ore sold for export, tons	140,608
Lead, lb..............................	41,593,680
Molybdenite, MoS_2 contents, lb.	159,000
Nickel, lb.	82,958,564
Platinum, oz.	15
Silver, oz............................	25,669,172
Zinc, lb.	23,515,030
Non-metallic:	
Actinolite, tons	250
Arsenic, white, tons	2,186
Asbestos, tons.....................	136,016
Asbestic, tons......................	18,500
Chromite, ore and concentrate, tons	13,834
Coal, tons............................	14,461,678
Corundum, tons	67
Felspar, tons	19,166
Fluorspar, tons	1,284
Graphite, tons.....................	3,971
Gypsum, tons......................	341,618
Magnesite, tons	55,413
Manganese, tons..................	979
Mica, tons	914
Mineral pigments—	
Barytes, tons...............	1,368
Oxides, tons	8,811
Petroleum, bbl.	198,123
Phosphate, tons	203
Pyrites, tons	309,411
Quartz, tons........................	135,803
Salt, tons............................	124,033
Talc, tons	10,651
Tripolite, tons.....................	620

SPECIAL CORRESPONDENCE

JOHANNESBURG.

THE CONTRACT SYSTEM.—A Government Commission is now sitting on the contract system. It is difficult to know what to say or think about the proposal to abolish the contract system of payment for work done underground. If the contract system is abolished, the day's wage plus bonus will also have to go, as it must be considered a part and parcel of the contract system. The mines are always complaining about the inefficiency of white labour, a complaint for which there is ample justification. Here we have a proposal to abolish the only system which encourages efficiency among the white miners. Its abolition is bound to cause a considerable amount of discontent among the most skilled and efficient of miners, and will place a premium on inefficiency underground. There appears to be an impression among the men's leaders and some of the doctors that the contract system, by inducing the men to work harder and for a shorter period, so as to earn a big cheque, is the principal cause of miners' phthisis, while the Mines Department suggests that it is another form of speeding up and tends to increase the number of accidents. After all it is only another form of agitation against the piece-work system. While the proposed substitution of the day-wage system may reduce the migratory habits of some of the miners, it will undoubtedly drive many of the most efficient and skilled miners from the Rand. It will probably add in the long run to the costs of mining, and also to the difficulties of supervision, as there will be every inducement then to shirk as much hard work as possible, After all it is difficult to see why the Rand mines should be compelled to work on different lines from those which are considered necessary for success in all other mining fields of the world.

GEOLOGICAL SOCIETY.—At the annual meeting of the Geological Society of South Africa, just held at Johannesburg, Dr. P. A. Wagner, the retiring president, dealt with several interesting subjects in his address. For instance he mentioned that he agreed with the view advanced by Dr. E. T. Mellor that the gold occurring in the Rand conglomerates was of detrital origin. He could not, however, agree with the view of Dr. Mellor that the origin of the conglomerates themselves was due to the agency of violent floods, but rather that they were due to the action of waves and shore currents on a subsiding littoral of an extensive accumulation of bedded gravel. Dr. Wagner is regarded as the leading expert on diamonds, and in his address he brought forward evidence to prove that the diamond was susceptible to change under the influence of certain agencies which were known to be specially active at or near the earth's surface. He mentioned for instance that the yellow ground of the Premier mine near Pretoria yielded a much higher percentage of green diamonds than the blue ground of the same diamond pipe. This he considered was due to the influence of radium. He next referred to the extraordinary salt pan situated in the Pretoria district northwest of Hamman's Kraal, and years ago worked by the Barnato group for the production of common salt. It had since proved to be a most valuable deposit of trona or native soda, and several theories had been advanced to account for its origin. Some had described it as meteoric, others as due to a fault, while others to a volcanic origin. It was a most remarkable crater-like depression, and the volcanic theory of its origin was most probably the correct one.

STATE MINING COMMISSION.—This Commission has at last concluded taking evidence, the last witness called being the Government Mining Engineer, Mr. R. N. Kotze, with the object of confirming his former evidence, and advancing any further views or explanations the Commission might require. He commenced by stating that he had estimated that during the next ten years 27 mines would become exhausted. At the present time these 27 produced gold to the total value of twelve millions sterling. To balance this loss of producing mines it would, he estimated, require from 5 to 10 new mines say capable together of producing 6,500,000 tons of ore per year, He further estimated that during that time the existing mines, by making additions, might turn out an additional 2,500,000 tons. This evidence would seem to indicate that in ten years from date the production of gold in the Transvaal, or rather on the Rand, will have declined to about thirty millions sterling, unless half a dozen new mines are started on the Far East Rand immediately. It is also clear that in another five years' time a reduction in the production of gold on the Rand seems inevitable.

Dealing with the Far East Rand, Mr. Kotze stated that he thought 11,000 claims might be regarded as certain to prove payable, and another 6,000 claims might be regarded with less certainty in this respect. This left 200,000 claims about which it was not possible to speak with any certainty as to their ultimate value, and he considered it best to regard them as uncertain in value simply because no reliable data were available regarding them. Apparently very good terms had been secured by the Government for the areas just leased, but the most unpromising ground might in the end prove surprisingly good. In his opinion, if the State decided to go in for mining, some scheme would have to be devised to work the area as economically as possible. It must be admitted that the State would have the advantage from the point of view of lay-out. With regard to the desirability of the Government proving the ground before calling for tenders, he thought that if the State went so far as to sink shafts for that purpose, they might as well go in for State mining straightaway. Bore-holes were quite useless for proving the value of a reef; they could only be relied upon to prove its existence and depth. Owing to the difference in dip the yield per claim was much less than on the Central Rand. He considered that his original estimate of 450 millions as the value of the gold in the Far East Rand was conservative, as one farm only, namely, Modderfontein, might prove to be worth 135 millions sterling.

EAST RAND PROPRIETARY MINES.—Surprise will not be expressed, after what has already been stated about the condition of affairs at the East Rand Proprietary Mines, that the superintending engineer, Mr. W. T. Anderson, should deem it advisable to resign his appointment, and prefer to undertake war work in Europe. The unfortunate cross-cut south from No. 27 Level Angelo Deep had no sooner started than it struck a feeder of water, nearly five million gallons per day in capacity, which at a vertical depth of 4,000 ft. took some handling. By cutting off the other feeders, and concentrating pumping and baling operations on this new feeder, the bulk of the water was, however, dealt with. A portion of the feeder, however, ran into the Angelo Deep incline shafts. A dam has now been constructed at the entrance to the cross-cut, and the flow got under control. The striking of this additional feeder will involve the installation of more pumps. The opinion is expressed locally that as a source of water for the Rand Water Board the Angelo Deep promises to be a success at the 27th level, but as the average assay of the reef is only 1½ dwt. over a width of 24 in., the gold prospects are anything but encouraging. It was anticipated that with so much water the reef ought to carry better values. The prospects of ever striking the reef by cross-cuts and shaft-sinking at a depth of 6,000 feet as proposed are not very encouraging. To continue the Angelo Deep incline shafts in the foot-wall of the reef with so much water in the neighbourhood will also prove to be anything but an easy task.

WARD-LEONARD VERSUS THREE-PHASE WINDING SYSTEMS. — When electric winding was being installed throughout the Rand in 1911, there were some lively discussions about the respective merits of the Ward-Leonard and the three-phase systems of electric winding. The Ward-Leonard system was championed by Mr. Renner of the General Mining and Finance group, and the three-phase system by Prof. Heather, then of the Corner House group. The general impression formed at that time was that the Ward-Leonard system would come off the best, and that opinion seems to have been confirmed by actual practice. H. W. Clayden has just read an interesting paper on the two systems, the Ward-Leonard at the Meyer & Charlton mine, and the three-phase at the Van Ryn mine, of which the following are the particulars:

	Meyer & Charlton Ward-Leonard	Van Ryn Three-Phase
H.P. of Winder	500	550
Size of Drums	10 ft. by 3 ft. 6 in.	10 ft. by 3 ft. 6 in.
Gearing	Direct	4 to 1
Maximum Rope Speed	2,000 ft.	2,000 ft.
Shaft	Incline	Incline
Shaft Angle	45 to 27°	45 to 30°
Size of Rope	1¼ in.	1¾ in.
Capacity of Skip	5 tons	5 tons
Max. vertical depth of Wind.	2,060 ft.	1,583 ft.
Maximum length of Wind	3 902 ft.	2,420 ft.

The average monthly cost of these two winders over three months, April to June 1916 inclusive, was given as follows in pence per useful shaft h.p.-hour:

	Ward-Leonard	Three-Phase
Average Shaft H.P. Hours	25,436	26,124
Attendance, Oil, & E. R. Stores	0·158d.	0·161d.
Repairs, Wages, and Stores.	0·097d.	0·292d.
Power	0·893d.	1·038d.
Total Cost	1·148d.	1·491d.

PERSONAL

MILTON A. ALLEN is representative in New York of the firm of Arthur L. Pearse & Co.

P. M. ANDERSON has been appointed consulting engineer for A. Goerz & Co.

H. C. BAYLDON has been appointed manager of the Spassky and Atbasar copper mines belonging to the Spassky Copper Mine, Limited.

DAVID W. BRUNTON has gone from the United States to China.

J. M. CAIRNS is home from Baluchistan.

E. H. CLIFFORD is expected from South Africa.

ARTHUR A. COLE has been re-elected president of the Canadian Mining Institute.

EDGAR A. COLLINS is going to Siberia as manager of the Ridder mine.

C. A. CORDER is resigning as manager of the Angelo section of East Rand Proprietary Mines, and will in future devote himself to farming.

WILLIAM CROSLEY has been appointed manager for the London and Burmese Wolfram Co. Ld., and is proceeding to Tavoy.

WALTER DOUGLAS succeeds Dr. James Douglas as president of Phelps, Dodge & Co.

CAPTAIN GEORGE FAIRBAIRN, of the Royal Engineers, has been awarded the Military Cross.

J. G. FOLEY has been promoted captain and battery commander in the Gold Coast East African Expeditionary Force.

HENRY J. GIFFORD will retire shortly from the management of the Champion Reef mine, India, and will be succeeded by C. F. HEATHCOTE.

A. GOLDWATER has left for Naraguta, Nigeria.

R. T. HANCOCK is expected here from Nigeria.

H. C. HOOVER has returned from America.

HENRY M. HOWE has been awarded the John Fritz medal.

H. W. HUTCHIN has been elected president of the Cornish Institute of Engineers.

J. P. HUTCHINS, of Petrograd, recently paid a visit to the Caucasus.

C. H. JONES has returned to Spassky, Siberia.

COURTENAY DE KALB has rejoined the staff of the *Mining and Scientific Press* as associate editor.

BENJAMIN MADEW has resigned the position of consulting engineer to the Goerz group.

MALCOLM MACLAREN has left for Peru.

S. MACPHAIL has been appointed manager of the Geduld mine.

EDWARD P. MATHEWSON was presented with the medal of the Mining and Metallurgical Society of America at the meeting of the Canadian Mining Institute on March 8.

F. F. MATHIEU has gone to the Belgian Congo.

C. W. PURINGTON has moved his office from 62 London Wall to 6 Copthall Avenue.

J. B. SCRIVENOR, Inspector of Mines for the Federated Malay States, is with the A Company, Inns of Court O.T.C., at Berkhamstead, Hertfordshire.

R. C. SHARP has returned from the Argentine.

SYDNEY W. SMITH, of the Royal Mint, has received the degree of D.Sc., London University, for his thesis on surface tension and cohesion in metals and alloys.

J. ERNEST SNELUS, manager for the Kaduna Syndicate Ld., left for Nigeria on March 28.

E. G. SUDLOW has been appointed manager of the Government Gold Mining Areas Modderfontein mine.

E. A. WALLERS has been re-elected president of the Transvaal Chamber of Mines.

A. STANLEY WILLIAMS is home on holiday from Northern Nigeria.

HORACE V. WINCHELL has gone from the United States to Siberia.

JOHN YATES is intending to retire from teaching in Johannesburg shortly. He has been most successful in this direction and attracted a great number of students in mining. In earlier days he was one of the pioneers of the cyanide process.

GEORGE S. YOUNG is going to the Belgian Congo.

H. A. KELLER was accidentally killed while on a visit of inspection at Clifton, Arizona. He was born in Philadelphia, and was a graduate of the University of Pennsylvania. As a metallurgist, he was best known in this country in connection with the copper smelter of the Mountain Copper Co., at Keswick, California, and for his research on the Ellershausen zinc-lead process.

METAL MARKETS

COPPER.—After opening the month with a strong market which carried standard up to £140 cash and £137. 10s. three months, prices gave way and became settled at a steady level of £136–£136. 10s. cash and £135. 10s. to £136 three months. There is no great volume of business in evidence, most of the copper required in this country being furnished by the departments concerned. In America sellers are reserved, and prices ruling there have ranged from 34 to 36 cents. That their demands represent a highly inflated value is shown in their patriotic action in placing large quantities of the metal at the disposal of the United States Government at a heavy sacrifice in price. Production goes on satisfactorily, and, it is understood, may again attain early in the summer the high figures reached at the end of last year.

Average prices of cash standard copper: March 1917, £137. 1s. 2d.; February 1917, £138. 5s. 9d.; March 1916, £106. 19s. 11d.

SPELTER.—Prices have been irregular in tone and little business has been done. American producers hold for full prices, but buyers do not appear to be attracted, and trading shows a lull. An order has been issued by the authorities prohibiting dealings in spelter except under license or its use unless for Class A work. The immediate effect was a heavy fall in values which, however, recovered almost immediately.

Average prices of good ordinary brands: March 1917, £54. 10s. 4d.; February 1917, £54. 4s. 6d.; March, 1916, £90. 1s. 9d.

LEAD.—Official prices are still quoted £30. 10s. to £29. 10s. In America the quotation stands at 9 cents, but there have been no American supplies reaching this side for a long time past. Heavier shipments are reported from Spain, requisitioned steamers having been put in to lift the accumulated stocks.

Average prices of soft foreign pig lead: March 1917, £30; February 1917, £30; March 1916, £34. 7s. 8d.

TIN.—This market has been strong, and from £199. 10s. cash and three months the official quotation for standard was forced up to £215 for both positions. The fall in silver was expected to assist the export of Chinese tin, but there seems little available, political disturbances having seriously affected the output. There has been latterly a marked disposition in America to hold off the market. This may be due to the heavy arrivals there in the past week, when nearly 2,000 tons found their way into consumers hands. Continental demand has been brisk and a heavy inquiry is reported for Russia, although no actual business seems to have been put through yet. Home trade is moderately brisk.

Average prices of cash standard tin: March 1917, £207. 10s. 8d.; February 1917, £198. 19s. 3d.; March 1916, £193. 13s. 11d.

PLATINUM.—290s. per oz.; bought by Johnson, Matthey & Co. for the Government at 260s. per oz.

QUICKSILVER.—Under control and daily quotations suspended; price £20 to £25. per flask of 75 lb.

BISMUTH.—11s. per lb. CADMIUM.—7s. 9d. per lb.

MOLYBDENITE.—90% Mo S_2, 105s. per unit.

TUNGSTEN.—Wolfram and scheelite 65% WO_3, 55s. per unit; metallic powder 6s. 3d. per lb.

COBALT.—8s. per lb. NICKEL.—£225 per ton.

No price for antimony, aluminium, manganese or chrome ores.

SILVER.—The market has lost some of its strength and the price receded from 38d. per oz. standard of two months ago to 35½d.; during the last few days the price has hardened to 35¾d.

PRICES OF CHEMICALS. April 4.

Owing to the war, buyers outside the controlled firms have a difficulty in securing supplies of many chemicals, and the prices they pay are often much higher than those quoted below.

		£	s.	d.
Acetic Acid, 40%	per cwt.	2	17	6
,, 60%	,,	3	12	6
,, Glacial	,,	7	15	0
Alum	per ton	15	0	0
Alumina, Sulphate of	,,	18	10	0
Ammonia, Anhydrous	per lb.		1	9
,, 0·880 solution	per ton	32	10	0
,, Chloride of, grey	per cwt.	1	18	0
,, ,, ,, pure	,,	3	10	0
,, Nitrate of	per ton	75	0	0
,, Phosphate of	,,	85	0	0
,, Sulphate of	,,	15	10	0
Arsenic, White	,,	60	0	0
Barium Chloride	,,	30	0	0
,, Carbonate	,,	10	0	0
,, Sulphate	,,	5	0	0
Bleaching Powder, 35% Cl.	,,	29	0	0
Borax	,,	37	0	0
Carbolic Acid, 60% Crude	per gal.		3	6
China Clay	per ton	1	10	0
Copper, Sulphate of	,,	65	0	0
Cyanide of Potassium, 98%	per lb.		1	0
,, ,, Sodium, 100%	,,			10
Hydrofluoric Acid	,,			6
Iodine	,,		11	4
Iron, Sulphate of	per ton	4	15	0
Lead, Acetate of, white	,,	85	0	0
,, Nitrate of	,,	65	0	0
,, Oxide of, Litharge	,,	45	0	0
,, White	,,	47	0	0
Magnesite, Calcined	,,	15	0	0
Magnesium Sulphate	,,	10	10	0
Oxalic Acid	per lb.		1	7
Phosphoric Acid	,,			10
Potassium Bichromate	,,		1	4
,, Carbonate	per ton	115	0	0
,, Chlorate	per lb.		2	6
,, Chloride 80%	per ton	65	0	0
,, Hydrate, (Caustic) 90%	,,	300	0	0
,, Nitrate	,,	75	0	0
,, Permanganate	per lb		12	6
,, Prussiate, Yellow (Ferricyanide)	,,		4	0
,, Sulphate, 90%	per ton	65	0	0
Sodium Metal	per lb		1	3
,, Acetate	per ton	70	0	0
,, Bicarbonate	,,	7	5	0
,, Carbonate (Soda Ash)	,,	7	0	0
,, ,, (Crystals)	,,	3	5	0
,, Hydrate, 76%	,,	24	0	0
,, Hyposulphite	,,	13	0	0
,, Nitrate, 95%	,,	23	10	0
,, Phosphate	,,	29	0	0
,, Silicate	,,	7	0	0
,, Sulphate (Salt-cake)	,,	2	2	6
,, ,, (Glauber's Salts)	,,	3	10	0
,, Sulphide	,,	21	0	0
Sulphur, Roll	,,	32	0	0
,, Flowers	,,	35	0	0
Sulphuric Acid, non-arsenical 140°T.	,,	4	5	0
,, non-arsenical 95%	,,	7	0	0
Superphosphate of Lime, 18%	,,	5	10	0
Tin Crystals	per lb.		1	6
Zinc Chloride, solution 100°T.	per ton	25	0	0
Zinc Sulphate	,,	25	0	0

STATISTICS.

Production of Gold in the Transvaal.

	Rand	Elsewhere	Total	Value
	Oz.	Oz.	Oz.	£
Year 1912	8,753,563	370,731	9,124,299	38,757,560
Year 1913	8,430,998	363,826	8,794,824	37,358,040
Year 1914	8,033,567	344,570	8,378,139	35,588,075
Year 1915	8,772,919	320,752	9,073,671	38,627,461
January 1916	759,852	27,615	787,467	3,344,948
February	727,346	26,248	753,594	3,201,063
March	768,714	27,975	796,689	3,384,121
April	728,399	26,273	754,672	3,205,643
May	751,198	26,483	777,681	3,303,377
June	735,194	26,570	761,764	3,235,767
July	733,485	27,602	761,487	3,232,891
August	752,940	28,210	781,150	3,318,116
September	744,881	26,686	771,567	3,277,408
October	764,489	27,850	792,339	3,365,642
November	756,370	26,696	783,066	3,326,253
December	748,491	25,971	774,462	3,289,705
Year 1916	8,971,359	324,179	9,295,538	39,484,934
January 1917	756,997	25,637	782,634	3,324,418
February	696,955	24,366	721,321	3,063,976

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
January 31, 1916	209,835	9,228	802	219,865
February 29	209,426	9,468	970	219,864
March 31	203,575	9,588	917	214,080
April 30	199,936	9,827	938	210,701
May 31	194,765	9,811	1,459	206,035
June 30	192,809	9,859	2,105	204,773
July 31	192,130	9,932	3,339	205,401
August 31	194,112	10,086	5,146	209,344
September 30	197,734	10,239	6,527	214,500
October 31	199,330	10,907	6,358	216,595
November 30	196,132	11,118	5,928	213,178
December 31	191,547	11,487	5,194	208,228
January 31, 1917	188,624	11,611	5,591	205,826
February 28	191,095	11,568	6,268	208,931

Cost and Profit on the Rand.

Compiled from official statistics published by the Transvaal Chamber of Mines. The profit available for dividends during 1915 was 63% of the working profit.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
Year 1912	25,486,361	29 2	19 3	9 11	12,678,095
Year 1913	25,628,432	27 9	17 11	9 6	12,189,105
Year 1914	25,701,954	26 6	17 1	9 0	11,553,697
Year 1915	28,314,539	26 3	17 5	8 5	11,931,062
January 1916	2,449,518	26 1	17 10	7 10	962,120
February	2,297,276	26 8	18 4	8 0	924,310
March	2,455,019	26 5	18 1	8 0	979,234
April	2,291,231	26 10	18 2	8 4	951,247
May	2,382,298	26 7	18 2	8 2	977,263
June	2,296,520	27 0	18 3	8 6	977,681
July	2,370,244	26 1	17 10	8 0	949,606
August	2,423,669	26 3	17 10	8 1	976,125
September	2,367,793	26 6	18 0	8 3	972,704
October	2,453,437	26 4	17 10	8 2	1,001,843
November	2,389,056	26 9	18 2	8 2	980,387
December	2,349,191	26 10	18 2	8 4	977,481

Production of Gold in Rhodesia and West Africa.

	Rhodesia.		West Africa.	
	1916	1917	1916	1917
	£	£	£	£
January	318,586	296,113	140,579	131,665
February	313,769	289,734	137,739	104,892
March	335,368	...	150,987	...
April	339,386	...	135,976	...
May	323,783	...	132,976	...
June	333,070	...	127,107	...
July	322,365	...	128,574	...
August	338,001	...	125,143	...
September	322,035	...	127,138	...
October	325,608	...	132,577	...
November	317,135	...	130,101	...
December	306,205	...	146,409	...
Total	3,895,311	585,847	1,615,306	236,557

Western Australian Gold Statistics.

	Reported for Export oz.	Delivered to Mint oz.	Total oz.	Total value £
January 1916	1,861	92,124	93,985	399,220
February	2,832	65,138	67,970	288,717
March	5,600	88,393	93,993	399,255
April	2,926	87,601	90,527	384,532
May	577	83,301	83,878	356,289
June	2,070	92,612	94,682	402,181
July	912	91,725	92,637	393,495
August	*	89,522	*	*
September	*	85,978	*	*
October	*	82,732	*	*
November	*	87,322	*	*
December	*	88,205	*	*
January 1917	*	83,962	*	*
February	*	81,810	*	*
March	*	76,171	*	*

* By direction of the Federal Government the export figures will not be published until further notice.

Australian Gold Returns.

	Victoria.		Queensland.		New South Wales	
	1916	1917	1916	1917	1916	1917
	£	£	£	£	£	£
January	89,900	...	66,700	50,150	39,000	29,000
February	76,500	...	79,050	...	30,000	26,000
March	103,600	...	76,920	...	36,000	...
April	60,000	..	83,300	...	63,000	...
May	119,500	...	116,230	...	19,000	...
June	86,000	...	72,200	...	18,000	...
July	100,600	...	85,400	...	23,000	...
August	66,800	...	86,000	...	24,000	...
Septem.	115,100	...	65,450	...	32,000	...
October	81,400	...	74,800	...	32,000	...
Novem.	94,000	...	60,300	...	31,000	...
Decem.	96,600	...	73,550	...	111,000	...
Total	1,090,000	...	940,500	50,150	459,000	55,000

Production of Gold in India.

	1914	1915	1916	1917
	£	£	£	£
January	193,140	201,255	192,150	190,047
February	185,508	195,970	183,264	180,904
March	191,853	194,350	186,475	...
April	189,197	196,747	192,208	...
May	193,031	199,786	193,604	...
June	192,224	197,447	192,469	...
July	195,137	197,056	191,404	...
August	196,560	197,984	192,784	...
September	195,843	195,952	192,330	...
October	198,191	195,531	191,502	...
November	197,699	192,714	192,298	...
December	211,911	204,590	205,164	...
Total	2,340,259	2,366,457	2,299,568	370,951

Daily London Metal Prices

Copper, Lead, Zinc, Tin, in £ per long ton. Silver in pence per standard ounce.

	Copper			Lead	Zinc	Tin Standard	Silver
	Standard	Electrolytic	Best Select'd				
Mar.	£	£	£	£ s.	£ s.	£ s. d.	d.
12	136	151	149	30 10	56 0	200 5 0	$36\frac{7}{8}$
13	136	151	149	30 10	57 0	200 15 0	$36\frac{1}{2}$
14	136	151	149	30 10	57 0	202 0 0	36
15	136	151	149	30 10	57 0	203 15 0	$35\frac{7}{8}$
16	136	151	149	30 10	56 15	205 0 0	$35\frac{7}{8}$
19	136	151	149	30 10	57 15	208 15 0	$36\frac{3}{16}$
20	136	151	149	30 10	58 0	213 15 0	$35\frac{13}{16}$
21	136	151	149	30 10	58 0	211 0 0	$35\frac{7}{8}$
22	136	151	149	30 10	57 15	213 0 0	$35\frac{7}{8}$
23	136	151	149	30 10	51 0	216 5 0	$35\frac{13}{16}$
26	136	151	149	30 10	55 0	218 0 0	$35\frac{3}{4}$
27	136	151	149	30 10	55 0	218 0 0	$35\frac{11}{16}$
28	136	151	149	30 10	55 0	217 0 0	$36\frac{1}{8}$
29	136	151	149	30 10	55 0	215 5 0	$35\frac{15}{16}$
30	136	151	149	30 10	55 0	214 15 0	36
April							
2	136	151	149	30 10	55 0	215 10 0	$36\frac{13}{16}$
3	136	151	149	30 10	55 0	214 0 0	$36\frac{13}{16}$
4	136	151	149	30 10	55 0	215 15 0	$36\frac{3}{4}$
5	136	151	149	30 10	55 0	216 5 0	$36\frac{5}{8}$

Imports of Ores and Metals into United Kingdom.

These figures do not include Government imports.

Long tons.

	Year 1916	Jan. 1917	Feb. 1917	Year 1917
	Tons	Tons	Tons	Tons
Iron Ore	6,905,936	511,804	507,560	1,019,364
Copper Ore	34,492	1,949	1,687	3,636
,, Matte and Precipitate	43,839	2,091	1,247	3,338
,, Metal	111,412	7 981	7,016	16,997
Copper and Iron Pyrite	951,206	92,000	86,920	178,920
Tin Concentrate	33,912	1,497	6,499	7,996
,, Metal	33,646	2,213	2,193	4,406
Manganese Ore	439,509	32,047	29,767	61,814
Lead, Pig and Sheet	157,985	11,929	10,087	22,016
Zinc (spelter)	53,324	6,938	4,150	11,108
	lb.	lb.	lb.	lb.
Quicksilver	2,556,214	47,044	2,800	49,844

Exports of Copper from United States

Reported every month by the United States Customs.

1916	Long tons	1916	Long tons	1917	Long tons
January	21,863	July	35,048	January	25,540
February	20,548	August	34,700	February	24,937
March	24,006	September	28,572	March	—
April	19,980	October	32,712	April	—
May	14,700	November	21,433	May	—
June	38,277	December	21,438	June	—
		Total 1916	313,277	Total 1917	50,477

Outputs of Tin Mining Companies.

In Tons of Concentrate.

	Year 1916	Jan. 1917	Feb. 1917
	Tons	Tons	Tons
Bisichi (Nigeria)	473	40	32
Briseis (Tasmania)	467	34	30
Dolcoath (Cornwall)	1,076	60	62
East Pool (Cornwall)*	1,012	88	87
Gopeng (F.M.S.)	1,113	92	76
Malayan Tin (F.M.S.)	1,104	65	62
Mongu (Nigeria)	576	60	60
Naraguta (Nigeria)	523	48	44
N. N. Bauchi (Nigeria)	578	45	40
Pahang (F.M.S.)	2,591	220	220
Rayfield (Nigeria)	658	50	50
Renong (Siam)	894	82	61
Siamese Tin (Siam)	906	81	73
South Crofty (Cornwall)*	700	55	55
Tekka-Taiping (F.M.S.)	651	47	30
Tongkah Harbour (Siam)	1,135	96	87
Tronoh (F.M.S.)	1,662	108	83

* Including Wolfram

Stocks of Tin.

Reported by A. Strauss & Co Long tons.

	Jan. 31, 1917	Feb. 28, 1917	Mar. 31, 1917
	Tons	Tons	Tons
Straits and Australian, Spot	1,659	907	1,735
Ditto, Landing and in Transit	835	2,020	1,245
Other Standard, Spot and Landing	1,252	995	694
Straits, Afloat	4,080	5,994	5,314
Australian, Afloat	370	450	425
Banca, on Warrants	—	—	—
Ditto, Afloat	1,955	1,918	3,738
Billiton, Spot	—	—	—
Ditto, Afloat	473	100	117
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	745	1,613	1,121
Afloat for United States	4,517	3,625	3,455
Stock in America	4,622	3,027	3,362
Total Stock	18,508	20,649	21,206

4—4

Shipments and Imports of Tin

Reported by A. Strauss & Co. Long tons.

	Year 1916	Feb. 1917	Mar. 1917	Total 1917
	Tons	Tons	Tons	Tons
Shipments from:				
Straits to U.K.	27,157	4,264	2,200	8,369
Straits to America	25,943	1,048	2,060	5,273
Straits to Continent	8,487	943	874	2,562
Australia to U.K.	2,537	95	15	349
U.K., Holland, and Continent to America	14,863	1,035	1,755	4,340
Imports of China Tin into U.K. and America	1,305	5	—	5
Imports of Bolivian Tin into Europe	15,116	2,968	1,039	4,534
Deliveries in U.K.	16,862	1,117	1,424	3,756
,, ,, Holland	943	85	98	288

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note *These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.*

	1912	1913	1914	1915	1916	1917
	Tons	Tons	Tons	Tons	Tons	Tons
January	204	466	485	417	531	648
February	240	427	469	358	528	627
March	247	510	502	418	547	...
April	141	430	482	444	486	...
May	144	360	480	357	536	...
June	121	321	460	373	510	...
July	140	357	432	455	506	...
August	201	406	228	438	498	...
September	196	422	289	442	535	...
October	256	480	272	511	584	...
November	340	446	283	467	679	...
December	310	478	326	533	654	...
Total	2,540	5,103	4,708	5,213	6,594	1,275

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters.

Long Tons.

	1913	1914	1915	1916	1917
	Tons	Tons	Tons	Tons	Tons
January	4,121	4,983	4,395	4,316	3,558
February	3,823	3,555	3,780	3,372	2,755
March	3,562	3,839	3,653	3,696	3,286
April	4,066	4,087	3,619	3,177	...
May	4,319	4,135	3,823	3 729	...
June	3,993	4,303	4,048	3,435	...
July	4,245	4,582	3,544	3,517	...
August	4,620	3,591	4,046	3,732	...
September	4,379	3,623	3,932	3,636	...
October	4,409	3,908	3,797	3,681	...
November	3,976	4,085	4,059	3,635	...
December	4,614	4,351	4,071	3,945	...
	50,127	49,042	46,767	43,871	9,599

Sale of Tin Concentrate at Redruth Ticketings.

	Long tons	Value	Average
Year 1915	4,918	£448,362	£90 14 6
July 3, 1916	179	£17,477	£97 12 10
July 17	186½	£17,114	£91 15 4
July 31	172¼	£16,172	£93 17 8
August 14	166	£15,955	£96 2 4
August 28	180¼	£17,345	£96 4 8
September 11	184	£17,113	£93 0 2
September 25	166½	£15,980	£95 19 7
October 9	197	£19,443	£98 13 11
October 23	170	£17,167	£100 19 9
November 8	194½	£19,701	£101 5 10
November 20	172	£18,044	£104 18 2
December 4	160½	£16,588	£105 4 6
December 18	186¼	*	*
Total, 1916	4,668	£478,194	—
January 2, 1917	176	*	*
January 15	160¾	£16,681	£103 15 5
January 29	152	£16,095	£105 17 10
February 12	182¼	£20,649	£113 6 1
February 26	176¾	£19,700	£111 9 3
March 12	179	£20,468	£114 7 0
March 26	161¾	£19,875	£122 17 8

* Prices not published.

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	April 5, 1916 £ s. d.	April 2, 1917 £ s. d.
Rand:		
Bantjes	17 0	6 3
Brakpan	3 16 3	4 19 6
Central Mining (£8)	6 12 6	6 7 6
Cinderella	7 6	4 6
City & Suburban (£4)	1 15 0	1 14 6
City Deep	3 15 6	4 5 0
Consolidated Gold Fields	1 7 6	1 7 6
Consolidated Langlaagte	1 12 0	1 5 6
Consolidated Main Reef	19 3	17 3
Consolidated Mines Selection (10s).	17 3	1 3 0
Crown Mines (10s.)	2 13 9	2 12 6
Daggafontein	13 9	12 6
D. Roodepoort Deep	15 0	11 3
East Rand Proprietary	17 6	10 3
Ferreira Deep	1 17 6	1 3 9
Geduld	2 3 9	2 3 9
Geldenhuis Deep	1 2 6	1 1 3
Gov't Gold Mining Areas	1 14 3	2 17 6
Heriot	2 11 3	2 3 9
Jupiter	7 6	6 3
Kleinfontein	1 10 6	1 2 6
Knight Central	15 9	8 6
Knight's Deep	1 2 6	1 1 3
Langlaagte Estate	19 6	15 6
Luipaard's Vlei	8 9	6 6
Main Reef West	9 3	4 0
Meyer & Charlton	5 6 3	5 1 3
Modderfontein (£4)	16 2 6	19 2 6
Modderfontein B	5 18 9	7 11 3
Modder Deep	6 1 3	6 12 6
Nourse	16 3	1 2 6
Rand Mines (5s.)	3 13 0	3 7 0
Rand Selection Corporation	3 3 9	3 10 0
Randfontein Central	12 0	11 0
Robinson (£5)	1 0 0	16 3
Robinson Deep	1 0 6	1 10 0
Rose Deep	1 7 6	1 0 0
Simmer & Jack	7 6	5 9
Simmer Deep	2 6	4 0
Springs	2 13 0	2 17 6
Van Ryn	2 5 0	1 16 3
Van Ryn Deep	3 3 0	3 4 6
Village Deep	1 12 6	1 5 6
Village Main Reef	1 0 6	14 6
Witwatersrand (Knight's)	2 15 6	2 3 9
Witwatersrand Deep	1 6 3	17 6
Wolhuter	11 0	10 3
Other Transvaal Gold Mines:		
Glynn's Lydenburg	10 0	13 9
Sheba (5s.)	2 3	1 3
Transvaal Gold Mining Estates	1 5 6	17 0
Diamonds in South Africa:		
De Beers Deferred (£2 10s.)	10 17 6	13 2 6
Jagersfontein	3 7 6	4 10 0
Premier Deferred (2s. 6d.)	5 0 0	7 10 0
Rhodesia:		
Cam & Motor	10 9	7 9
Chartered British South Africa	10 6	11 6
Eldorado	9 0	7 9
Falcon	10 3	14 9
Gaika	12 6	8 9
Giant	7 0	5 3
Globe & Phœnix (5s.)	1 5 6	1 11 3
Lonely Reef	1 5 0	1 1 3
Shamva	1 14 6	1 2 6
Wanderer (3s.)	1 3	1 6
Willoughby's (10s.)	5 3	4 0
West Africa:		
Abbontiakoon (10s.)	7 9	4 9
Abosso	9 6	7 0
Ashanti (4s.)	19 0	19 6
Prestea Block A	10 0	5 9
Taquah	19 0	17 0
West Australia:		
Associated Gold Mines	5 0	3 0
Associated Northern Blocks	3 3	2 9
Bullfinch	4 6	2 0
Golden Horse-Shoe (£5)	1 18 9	1 15 0
Great Boulder Proprietary (2s.)	13 3	10 9
Great Boulder Perseverance	9	1 3
Great Fingall (10s).	2 3	1 0
Ivanhoe (£5)	2 5 0	2 1 3
Kalgurli	12 0	8 9
Sons of Gwalia	13 3	14 3

Gold, Silver, *cont.*	April 5, 1916 £ s. d.	April 2, 1917 £ s. d.
Others in Australasia:		
Mount Boppy, New South Wales	15 0	6 0
Talisman, New Zealand	12 6	7 6
Waihi, New Zealand	1 13 6	1 13 3
Waihi Grand Junction, New Z'lnd	19 3	15 0
America:		
Alaska Treadwell (£5), Alaska	6 10 0	2 15 0
Buena Tierra, Mexico	13 9	9 6
Camp Bird, Colorado	7 3	5 0
Canadian Mining, Ontario	9 6	—
Casey Cobalt, Ontario	3 6	6 6
El Oro, Mexico	8 3	7 0
Esperanza, Mexico	9 6	7 9
Frontino & Bolivia, Colombia	9 9	12 6
Le Roi No. 2 (£5), British Columbia	10 6	9 6
Mexico Mines of El Oro, Mexico	3 15 0	4 2 6
Oroville Dredging, California	14 3	16 0
Plymouth Consolidated, California	1 3 0	1 2 0
St. John del Rey, Brazil	15 0	15 0
Santa Gertrudis, Mexico	10 6	9 6
Tomboy, Colorado	1 1 6	19 6
Russia:		
Lena Goldfields	1 13 9	2 0 0
Orsk Priority	18 0	1 3 9
India:		
Champion Reef (2s. 6d.)	8 0	5 9
Mysore (10s.)	3 16 3	3 1 9
Nundydroog (10s.)	1 6 6	1 5 0
Ooregum (10s.)	1 3 0	1 0 0

COPPER:

Anaconda (£10), Montana	18 2 6	17 15 0
Arizona Copper (5s.), Arizona	1 16 0	2 3 9
Cape Copper (£2), Cape Province	3 2 6	4 2 6
Chillagoe (10s.), Queensland	6	3
Cordoba (5s.), Spain	4 6	3 6
Great Cobar (£5), N.S.W.	3 6	2 3
Hampden Cloncurry, Queensland	2 1 0	1 11 9
Kyshtim, Russia	2 4 6	2 10 6
Messina (5s.), Transvaal	11 3	10 6
Mount Elliott (£5), Queensland	4 2 6	5 10 0
Mount Lyell, Tasmania	1 8 6	1 6 3
Mount Morgan, Queensland	2 2 6	1 15 0
Rio Tinto (£5), Spain	62 0 0	63 0 0
Sissert, Russia	1 1 3	1 6 3
Spassky, Russia	2 0 0	2 0 0
Tanalyk, Russia	2 2 0	2 5 0
Tanganyika, Congo and Rhodesia	1 19 6	2 7 6

LEAD-ZINC:

Broken Hill:		
Amalgamated Zinc	1 8 6	1 10 6
British Broken Hill	1 8 6	1 7 3
Broken Hill Proprietary (8s.)	3 5 0	2 2 9
Broken Hill Block 10 (£10)	1 2 6	1 0 6
Broken Hill North	2 7 9	2 8 3
Broken Hill South	7 17 6	8 0 0
Sulphide Corporation (15s.)	1 3 0	1 5 3
Zinc Corporation (10s.)	14 6	15 9
Asia:		
Burma Corporation	1 14 6	3 15 0
Irtysh Corporation	2 0 0	2 3 0
Russian Mining	16 3	1 1 3
Russo-Asiatic	5 2 6	5 2 6

TIN:

Aramayo Francke, Bolivia	1 6 3	1 12 6
Bisichi, Nigeria	8 6	14 0
Briseis, Tasmania	4 9	4 9
Dolcoath, Cornwall	9 0	10 6
East Pool, Cornwall	1 13 9	1 15 6
Ex-Lands Nigeria (2s.), Nigeria	1 6	1 6
Geevor (10s.) Cornwall	—	13 3
Gopeng, Malay	1 12 6	1 8 9
Ipoh Dredging, Malay	1 0 6	15 0
Malayan Tin Dredging, Malay	1 18 9	1 18 9
Mongu (10s.), Nigeria	9 6	11 6
Naraguta, Nigeria	18 0	15 0
N. N. Bauchi Pref. (10s.), Nigeria	6 0	9 9
Pahang Consolidated (5s.), Malay	10 3	11 9
Rayfield, Nigeria	7 0	7 6
Renong Dredging, Siam	1 11 3	2 3 9
Ropp (4s.), Nigeria	17 0	17 6
Siamese Tin, Siam	2 15 0	2 3 9
South Crofty (5s.), Cornwall	12 0	19 0
Tekka, Malay	2 17 6	3 0 0
Tekka-Taiping, Malay	2 5 0	2 17 6
Tronoh, Malay	2 0 0	1 7 6

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also reviews of new books, and abstracts of the yearly reports of mining companies.

MINING AND PREPARATION OF CHINA CLAY.

The literature relating to china clay is not extensive. We published an article by the late Mr. J. H. Collins in June 1911 entitled "The China-Clay Industry of Cornwall." In 1915 the Geological Survey published a monograph by Mr. J. Allen Howe entitled "Kaolin, China-Clay, and China-Stone." The practical work of mining and treating the clay provided a subject for a paper read a year or so ago before the Royal Cornwall Polytechnic Society by Mr. J. M. Coon, a leading owner and operator in Cornwall. This paper has only just been printed, being issued in the 83rd Annual Report of the Society, as mentioned in our last issue. Mr. Coon's paper dealt with the development of mechanical appliances on china-clay works. We quote it herewith nearly in full.

The first china-clay works were opened and for a considerable time worked by such appliances as enabled the power of man to be applied to the work to be done. The lever, inclined plane, wheel and axle, and a wooden pump, all of simple form and comparatively rude construction, formed the machinery; the pick or dubber, shovel, steel-pointed borer, hammer, and stone fork or "evil," and a rake for removing the stent or stone debris, were the tools used in winning the clay, with equally simple mixing, separating, and cutting tools in preparing it for the market; reed-lined hurdles and sheds or "linhays" for storing it previous to shipment and transit to port by horse and cart formed the normal routine, all of these within the remembrance of the author.

The operations connected with the winning of china clay may be summarized under the headings: (1) Breaking the clay, rock, or ground; (2) Separation of the clay; (3) Pumping of clay-bearing water and draining the pit, haulage, etc.; (4) Disposal of waste; (5) Drying; (6) Transit to port.

(*1*) *Breaking the China-Clay Ground.*—Until within the last few years this has been accomplished by means of a special tool called a "dubber," doubtless developed from the ancient miner's pick. As this tool is used in the open and it is desirable to break out the comparatively soft yet tenacious ground in as large lumps as possible, the strength and weight is much increased, the steel point changed to a chisel-shaped edge, the eye provided with an extension at the back, and the handle greatly lengthened; but the most characteristic change is in the form of the blade, the gradually slight curve of the pick being, at about half-way between the point and the eye, replaced by a sharp bend. In use, effort is directed to force the blade into the ground as far as the bend. Often two or three blows are required. This wedging action sets up a strain or crack; the workman slowly lifts the handle, the bend of the blade is the fulcrum, and a large piece of ground is loosened. On continuing the upward motion of the handle, the upper part of the blade becomes the fulcrum, the broken piece is turned over and is pushed out of the way or thrown into the stream. This tool, therefore, is first a wedge, then a lever of the first kind with a shifting fulcrum.

Sometimes the clay-bearing rock is so soft that a stream of water allowed to fall on it from a small height so cuts and disintegrates it that little actual pick-work is required, except to assist in reducing the blocks which fall from the sides. As a development of this simple hydraulic method, about thirty-five years ago the West of England Co. applied the pressure method of hydraulicking with a Merryweather steam fire-engine. At that time they were not satisfied with the result. The experiment does not appear to have been repeated until, say, the last five years, consequent on the greatly increased demand and labour troubles. Now hydraulicking by jets of water under gravity pressure in the deeper works and by pressure pumps in the shallow ones is successfully applied and becoming very general. Where the depth of the pit produces a nozzle-pressure of 60 to 70 lb. the gravitation method is generally satisfactory; where less than this, pumps to increase the pressure are generally used. The type of pump varies, but will generally be three-throw or centrifugal pressure pumps, the motive power being producer gas-engines or Diesel oil-engines. Quite frequently these pressure pumps are electrically driven by combined motors, the electric energy being taken from a power station supplying one or more works. From 400 to 500 volts appears to be convenient for distribution. Messrs. Pochin in the St. Denis district, the Great Treverbyn C.C. Co., St. Austell, and the Dartmoor C.C. Co., have special and powerful installations for this purpose. In the latter case the pumps are directly driven by the engines, in the former by electric motors. High pressures up to 230 lb. are employed, especially when sinking the pits deeper.

(*2*) *Separation of the Clay.*—In separating the clay from the sand and mica of the clay rock, gravitation and sedimentation are relied on at all works except the Standardized C.C. Co., Ltd. Ranges of channels of various widths and lengths, through which the china-clay and mica flow very slowly, separate the mica from the clay, the sand having previously been deposited in large pits with adjustable outlet weirs capable of being raised as the pit is being filled. About ten years ago the author designed and constructed some conical elutriating pits to relieve the mica drags at Rosemellyn, which proved eminently satisfactory. Within the last few years a series of these pits have been installed at Roche china-clay works by Messrs. North and Rose. They have greatly increased the capacity and reduced the cost of cleaning the drags.

The Standardized C.C. Co. has installed an elaborate set of special machinery for the purpose of separating. The china-clay is removed from the pit as it is broken from the side in tubs hauled over an aerial ropeway to a platform, from whence it is fed into a revolving cylinder, provided internally with a projecting ridge forming a rapid screw. The cylinder is inclined downward, from the inlet where both the water and clay-ground are fed. It revolves so that the screw carries the sand or other debris backward while the clay and mica are carried forward by the water. The clay and mica enter a centrifugal machine where the coarsest mica is separated from the clay stream, which then passes on to the separator house, where ten Gee's patent centrifugal separators are installed. The clay-laden stream is fed from a long trough, filled with continuous stirrers, into the separators, which are so adjusted as to dimensions, etc., that when rotated at 700 revolutions per minute the fine mica and clay are graded from fine mica at the top to extremely fine clay at the bottom. Those acquainted with the principle on which such machines work will understand that the grading will depend on the peripheral speed of the machine and the fineness and specific gravity or mass of the material dealt with, the best results being obtained from very evenly grained material, or where various sizes of grain exist with material of the same specific gravity. The author has microscopically examined some of the very finest clay graded by this machine. It is much finer than the average, but it still contains a proportion of the finest mica and tourmaline, this latter being readily detected when examined between crossed nicols. The whole of the works are laid out so as where possible to substitute mechanical appliances for manual labour. Until development has reached a further stage a more detailed account is not available.

(3) *Pumping*.—The early method of opening out a clay pit was to commence working on the side of a hill, taking a cutting into it until the clay was reached, then widening out to uncover the clay-ground, the clay debris being removed through the cutting at the lowest level. After the clay had been separated and settled in the pits, it was necessary to raise it out of these pits for purposes of more rapid concentration and drying. This was accomplished by simple wooden pumps, the smaller ones being bored logs of wood about 9 ft. long. The method of boring the log was to place it horizontally on two trestles and fix it to them. Saw-cuts central and at right angles were made across each end. In these saw-cuts pieces of straight iron were inserted to act as sights. The borer or auger was supported on a third trestle, which raised its stem to the central line of the log, and its long cross handle allowed it to be set in line with the iron sights. Blocks of wood on each side kept it from moving sideways. It was thus supported centrally, and its alignment could always be corrected by the sights. The bucket or piston was a simple turned wood one with nailed-on cup, leather packing and weighed leather flap-valve, a long connected-rod joined with the lever handle at the top, and a bolted-on spout at the outlet completed this primitive but very useful machine. To reach greater depths a further similarly bored extension was used, fitted on with taper plug joints, "bal shag," etc., to staunch the joint. Such a pump would be used by one man or woman.

Pumps of larger capacity were made square from planed planks bolted together, provided with iron plates to keep the wood from buckling. These were made up to 6 or 7 inches square, and required four to work them, generally two men and two women. With increasing demand pumps of larger capacity worked by waterwheels came into use. These had cast iron cylinders and wrought iron buckets. It was generally thought that when works got beyond draining by such simple methods they could not be profitably worked and many were consequently abandoned.

It is doubtful when steam power was first applied to china-clay working, but probably one of the first works was North Goonbarrow, where the original steam engine is still at work and rendering excellent service. It may be called an inverted vertical engine. The cylinder is on the floor level on which it rests, and is attached to the floor joists. The girders for the piston-rod cross-head guides are formed by upright wood posts with wrought iron sliding-plates. The crank axle bearings are bolted to these posts. These particulars are of historic interest. The general application of steam power followed the lines of the usual mining practice of the country, the Cornish engine, either the direct acting or the rotary, having preference. In the case of smaller engines the horizontal type appears to have a marked preference over the vertical. These engines were almost exclusively of local manufacture.

When all circumstances are taken into account it is doubtful if the direct acting Cornish engine has any equal for mining, and one frequently hears of very wonderful examples of durability, reliability, and economy. A short time since a gentleman accustomed to Midland colliery practice remarked as he looked at one of them working, and, referring to the low cost of upkeep, that probably the high-pressure, high-expansion, and high-speed plant worked out in figures somewhat more economically, yet he felt that the great relief from anxiety as to breakdowns was much in favour of the Cornish engine, of which, he said, "it looks as if it will go on for ever." These engines are too well known to need description. When the direct acting type is used the pumping shaft is under the outside end of the beam. If the rotary type, the shaft will be sufficiently distant to permit the use of long sweeps or connecting rods, generally of wood strengthened with iron, from the cranks to the "bobs" or levers over the shaft; or the shaft may be at a considerable distance necessitating the use of transmission connecting rods. The type of pump employed was universally that of the Cornish miners, the drawing or bucket piston being replaced by the long stroke plunger. The pump essentially consisted of the cylinder with its stuffing-box and plunger, the "H-piece" and "door-piece" containing the valves and connecting to the rising column and the wind-bore under the "H-piece." The considerable quantity of fine sand and mica passing through the pump inevitably causes much wear, but well-cared-for plungers may last in constant use over ten years. It is this unavoidable wear which so much militates against short-stroke and quick-acting pumps when used for lifting the gritty water.

About thirty-five years ago pumps of the Cameron type were used to save capital outlay, but the constant trouble with the leather buckets and the liners of the pumping cylinders led to their abandonment. When employed for pumping clear water they are, of course, admirable. Pulsometer pumps have been frequently employed for temporary requirements and emergencies, but not for continuous use. Centrifugal pumps have been seriously adopted during recent years. They were first applied in the special form of gravel pumps and attracted attention by the bulk of material handled. The power required close attention, and wear and tear is very considerable. No comparative figures are available to enable judgment to be formed as to their economy under such circumstances, but the users have installed them at several new works. Whether their use can be continued when the works get deeper is doubtful. At another group of works centrifugal pumps of the sand type are used and regarded with much favour. Here again the height to which the load has to be lifted is small, and what will be the effect of increasing this height four or five times has yet to be ascertained. Comparative figures as to capital outlay, working costs, etc., are not available. As now applied the volume of water, clay, and sand lifted is certainly satisfactory. Such pumps must at present be considered as on their trial as far as china-clay working is concerned. They are nowhere in use in the deeper workings.

(4) *Disposal of Waste.*—The sand, mica, and hard portions of the ground worked, with the quartz and schorl of the veins which traverse it, form the waste products of china-clay working. In the early days these were removed by wheelbarrows through the open cutting and dumped on the hill-side. When larger quantities had to be dealt with small men-propelled tram waggons were used. At one works donkeys carried it out in panniers over inclined pathways up the sides. The application of mechanical power to the pumps demanded also power-hauling plant, and the inclined tramway with haulage chains became general, the source of power being a horse-driven whim or capstan, on which the chain was wound The waggon was received on a raised platform at the top of the pit. Subsequently the waggon was fitted with a self-tipping arrangement, the load being tipped into another tram and removed thereby to the end of the dump. If the drivers were not skilful in stopping the whims at the exact moment, the waggon might be pulled over the platform. The water-wheel and subsequently the steam-engine replaced the horse and man. At some Devon works the water-wheel still survives. At one place a most satisfactory and ingenious method of tele-operation is in use for starting and stopping both the load and the water supply to the wheel.

When rotary engines were first used the early practice was to do the winding by them as well as the pumping, the winding-drums being thrown in and out of gear by "dog" clutch couplings. The strain and irregularity of such procedure soon led to independent winding engines. This is now almost universal.

The approved practice at the present time with steam-power plant is an engine or a pair of engines geared directly to a revolving shaft carrying the cups of friction clutches keyed thereon. The winding-drums are mounted free on this revolving shaft and fitted on one side with wood-faced cones which, on being forced by levers into the fast cups, revolve and wind in the steel wire rope. The other side of the drum has a cast coned face which by the same levers engages the friction clutch and by a reversed motion forces the drum against the wood brake face to allow the waggon to be lowered into the pit. When electrical power is used the pattern of haulage drum is adapted to the electric motor of normal type.

From time to time other experimental methods have been applied to the removal of the sand waste. About thirty years ago a gentleman then fresh to the business installed a system of travelling dredger buckets, but it was soon abandoned. Aerial railways, or "blondins," have also from time to time been tried, and the Standardized C.C. Co. has a fine example of this method now in work. Whether it will prove sufficiently convenient has to be proved. In this the whole of the ground is brought out in tubs. After the separation of the clay the waste has to be removed. The method of doing so is not yet determined.

At Lee Moor massive masonry sand-pits of large dimensions are in use. Tram-lines run along each side under chutes by which the sand is filled into the self-tipping skips. These are hauled up, dumped, and a stream of water used to distribute the sand over a wide area, for obviously a wide tipping-ground and plenty of water are necessary. The most general method of distributing the sand is by man or boy propelled tram waggons over portable light railways, capable of easy removal to any required position.

About seven or eight years ago what are called "sky tips" came more prominently into vogue. These are arranged at the steepest convenient angle and provided at the top with overhanging rails. Self-tipping skips are hauled up by power and as they come on the overhanging rails are tipped. The tips are thus increased in height and extended at the same time.

(5) *Drying.*—The earliest commercial process was as follows: The clay, partly concentrated by settlement in deep pits, was run into shallow pits of considerable area with sand bottoms called "pans," to about twice the thickness of the desired layer of clay. Here by evaporation and filtration it gradually thickened. When firm enough to maintain its shape it was cut by a draw knife into blocks of convenient size for handling, stacked with air spaces between the blocks on the ground adjacent to the pans and protected from the rain by hurdles thatched with reed or rushes. When dry it was scraped by women, and stacked in open sheds called "linhays" until shipped. This was practically limited to summer time. The modification of this method resulting in covered pans with heated fires under and storage linhays adjacent is esteemed the best commercial method of drying, as it is independent of the weather and enables large quantities to be handled with economy of labour. The tonnage rate of cost, however, is about double that of the old method. An intermediate one, combining air and fire drying, is used with economy and success. The mechanical arrangements in use are practically limited to portable tramways and waggons in the concentrating tanks and a platform travelling the length of the kiln to facilitate the even distribution of the clay on the pan.

Many mechanical contrivances have been applied with the object of reducing the coal cost, such as blowing heated air through the wet clay, atomizing the concentrated clay by heated air under pressure, running the liquid clay into moulds and drying these in heated chambers, drying in heated chambers on travelling floors, or with the clay entangled in meshes of a travelling web, etc. None of these now survive. Filter presses are receiving a genuine trial on a commercial scale, with what success is not yet publicly known. Further improvements will doubtless result from the efforts to meet competition and increase of output.

(6) *Transit to Port.*—Transit to port was by one-horse carts carrying about one ton, then by waggons taking larger loads, the useful limit being waggons of about four tons capacity. About twenty years ago traction engines were introduced, but the low price at which horse labour was then able to work and irregular employment of the engines drove them off the road. More recently private owners who were able to arrange constant employment for their own plant have been more successful, but they are now practically out of use owing to the extension of the railway sidings at the various works. Pipelines for conveying the clay to drys situate at the railways and ports are now immensely reducing road transit.

This paper was discussed by Messrs. Stephen Vivian, F. J. Bowles, and the late J. H. Collins.

BISMUTH: ITS USES AND MARKETS.

Published information relating to bismuth is scarce; in fact the bismuth business is a close corporation, much to the disadvantage of the mines. Bolivia and Australia are the two biggest producers. The deposits in Queensland have received renewed attention, and the Biggenden mine is yielding important amounts of the metal. The Queensland Government Geologist, Mr. B. Dunstan, has recently collected information relating to the production, uses, and sale of bismuth ores, and his report is published in the *Queensland Government Mining Journal* for January. We quote herewith from the sections relating to uses and markets.

Numerous useful alloys are made by fusing bismuth with other metals, such as copper, tin, lead, and antimony. A small amount added to copper makes this metal red-short, or brittle when heated, and an alloy made by melting one part of copper to two parts of bismuth expands considerably on solidification; while one part of copper fused with four parts of bismuth produces a red crystalline alloy. Small quantities added to lead give toughness without brittleness, and two parts of bismuth with three of lead has ten times the hardness and twenty times the tenacity of lead, while two parts of lead and one of bismuth makes a very fusible and ductile alloy. Antimony fused with bismuth produces an alloy which expands when changing from a molten to a solid state, and equal quantities of both in an alloy produces a greater expansion than any other metal on solidification. Bismuth with tin forms alloys which are very sonorous, and to produce this effect in a marked degree some of the many plate and bell metals are made with bismuth as part of their composition. One part of bismuth to 24 of tin forms a malleable metal, which becomes brittle as the amount of bismuth is increased. Mercury is capable of absorbing a large quantity of bismuth in the formation of amalgams. Two of mercury to one part of bismuth forms a pasty mass, while with four parts of mercury the amalgam is in a liquid state. In the latter condition the amalgam is used in silvering both mirrors and the interior of vacuum flasks, although another alloy containing two parts of mercury and one each of of bismuth, lead, and tin is used for the same purpose.

Bismuth is alloyed with two or more suitable metals to produce expansion when cooling down to a solid state, and which at the same time should be an easily fusible composition, the principal metals used in producing these two effects being lead and tin, with zinc, antimony, cadmium, and mercury as accessory constituents. In making solders the melting point can be lowered if bismuth is alloyed with them, and soldering can be effected under boiling water if the right proportion, as shown in the table, is present.

FUSIBLE BISMUTH ALLOYS.
(*Fusible below the boiling point of water 212° F.*)

—	Bismuth M.P. 520°	Lead M.P. 621·1°	Copper M.P. 1981·5°	Tin M.P. 449·4	Cadmium M.P. 609·6	Mercury M.P. 37·7	Antimony M.P. 1166°	M. Point of Alloy
Charpy's eutectic	8	5	...	2½	...	...	...	204°
Newton's metal	8	5	...	3	...	...	...	201°
D'Arcet's metal	8	4	...	4	...	...	...	199°
Rose's metal	8	8	...	3	...	...	...	174°
Onion's mercuric	8	5	...	3	...	1½	...	170°
Lipowitz's metal	8	5	...	2	1	...	...	150°
Lipowitz's mercuric	8	4	...	2	2	1	...	143°
Wood's metal	7½	4	...	2	2	...	...	140°
Guthrie's eutectic	8	3	...	3	2½	...	...	very fusible
D'Arcet's mercuric	8	4	...	4	...	20	...	113°

The variations in expansion and contraction of bismuth alloys indicate that in making castings it is better, when convenient, to allow the metal to cool to a semi-fluid condition and to press instead of pour the metal into the moulds, as then it is nearing its minimum contraction. Stereotype metal and other metals used in printing are only occasionally made up with bismuth as one of the constituents, but where rough usage is expected, or where firmness and sharpness is specially desired, no other metal produces these qualities so effectively as bismuth.

Bismuth is useful in the processes of steel tempering. The exact degree of heat required for the purpose can be fixed automatically by using baths of molten alloys containing bismuth, which can be made up of varying proportions and giving fixed melting points.

As stated already, the presence of bismuth in an alloy gives low fusibility combined with hardness and sharp definition. The addition of cadmium to the bismuth-tin-lead series further lowers the fusing point, while the addition of mercury brings the temperature of fusion down to its lowest limits.

Safety plugs for boilers are made of an alloy of which bismuth is one of the constituents. The automatic sprinklers or fire extinguishers placed in the ceilings of buildings are also made of a bismuth composition and are set in action when material in a room takes fire, the rise in temperature immediately melting the easily fusible bismuth plugs and causing jets of water to play all over the room.

Electric fuses are sometimes made of a bismuth alloy, and are so constructed that if too great a charge of current is passed through them the easily fusible wire melts. This causes a disconnection and prevents any damage to the instruments or appliances within the circuit.

Bismuth is extremely diamagnetic, that is opposed to magnetic influence. Antimony is another diamagnetic metal, and with bismuth forms the couple of a delicate thermopile, an instrument used for measuring by thermo-electric force, indicated by a galvanometer, extremely minute changes in the heat of metals.

Bismuth bronzes suitable for spoons, jugs, teapots, &c., are alloys made up of a number of metals, and are said to be unoxidizable, to keep a good colour, and to be easily polished. Two such bronzes are of the following composition, respectively: (1) Copper, 25 parts; nickel, 24; antimony, 50; bismuth, 1; (2) copper, 69; nickel, 10; tin, 15; zinc, 20; aluminium, 1; bismuth, 1.

Bismuth subnitrate is used in surgical operations, in porcelain painting, as a medicine, and as a cosmetic. In medicine the carbonate is used much more than the subnitrate as it is very easily assimilated. The oxychloride of bismuth as a medicine is of special use as a preliminary to surgical operations on the stomach. Four ounces of this is taken and assimilated, after which the stomach and intestines are photographed by X-rays, the whole of the outline of these digestive organs, and their defects being clearly defined as a result of the sensitiveness of the bismuth to these rays. Bismuth salicylate, gallate, lactate, and other organic compounds are used as medicine and in surgical operations, but the demand for them is much smaller than that for the carbonate, subnitrate, and the oxychloride.

The oxide is used in porcelain painting and also in glass staining, the object of its introduction and also that of the subnitrate being to prevent certain substances producing colour which otherwise are useful fluxes. In gilding porcelain the oxide or the subnitrate is mixed with 15 times its weight of gold, applied with a brush, and then fired. The subnitrate gives a colourless but iridescent glaze to porcelain and produces a yellow glaze when mixed with chromic oxide. The addition of 5% of gold to the oxide makes a good copper-red glaze mixture, which has also the quality of producing a golden lustre by reflected light. With less gold the colour may be varied, and beautiful blue and violet shades can be produced by other proportions and manipulations of the same ingredients. In porcelain painting and enamelling the bismuth compounds may be generally used as a flux for increasing the fusibility of other colouring oxides, and therefore become a vehicle for the oxides of manganese, chromium, and copper. Mixed with the oxide of antimony the subnitrate forms Merinee's antimony yellow, which is a good body pigment, and quite permanent.

Selling prices of metallic bismuth in London during the last twelve years are given in the table, which indicates that the prices were lowest in 1906 and reached their maximum in 1916. In the United States at the beginning of 1915 the metal was quoted at 11s. 6d. per lb., and at the latter end of the year at 16s. 8d. per lb. [The quotation in England during 1915 and 1916 relates chiefly to the purchase of ore; the distribution of the metal and compounds is in the hands of the Government.]

Bismuth Prices in London.

Year	per lb. s. d.	Year	per lb. s. d.	Year	per lb. s. d.
1905	9 0	1909	6 6	1913	7 6
1906	5 0	1910	7 6	1914	10 0
1907	8 0	1911	7 6	1915	10 0
1908	6 6	1912	7 6	1916	11 0

In 1906, when values were lowest, the prices paid for bismuth per lb. by the Bismuth Association, less freight and other charges, were based on the percentage of the metal in the ore. Thus, 20% ore was paid for at the rate of 2s. 1d. per lb. of bismuth content (equal to £46. 13s. per ton), 25% ore was worth 2s. 3s. per lb., 30% was worth 2s. 4d., 35% 2s. 5d., 40% 2s. 6d., 50% 2s. 7d., 60% 2s. 8d., 70% 2s. 9d., 80% 2s. 10d. Any gold present to the extent of over ½ oz. was paid for at the rate of £4 per oz., less assay fee. Present arrangements do not show the prices so clearly, and are based on a buying price of 11s. per lb. of metal for ore containing over 15% of metal, and 10s. per lb. for ore containing less than this percentage. No penalties are inflicted for arsenic, antimony, or other metal although the first, particularly, is considered obnoxious.

Seven deductions are made against a consignment of ore in selling it to the Association, thus:

First —Less 10% [of weight?]
Second —Less 10% of assay value
Third —Less 2½% for association representative.
Fourth —£15 per ton for treatment. Further charge of 5s. per unit over 10% of bismuth after second deduction is made.
Fifth —Less 8% of [assay?] value as charges in forwarding to England.
Sixth —£8 per ton for incidental charges.

When wolfram is mixed with the bismuth, the prices paid vary with the percentages. If 5% of bismuth is present in the wolfram it is worth 2s. 5d. per lb. of metal contents, if 10% of bismuth is present it is worth 4s. 7d. per lb., 15% is worth 5s. 4d. per lb., and 20% is worth 5s. 8d. per lb., f.o.b.

In the case of bismuth-gold concentrates, it is stated that the bismuth is paid for at the rate of 3s. per lb., and the gold is penalized to the extent of £1 per oz. If these concentrates contain 3% of bismuth and 40 oz. of gold, as some of the last obtained at Mount Shamrock, Queensland, is said to contain, the following would be the difference between the buyers' valuation and the standard valuation of the metal contents:

	Buyer's Valuation.	Standard Valuation.
Bismuth content ...	£10	£33 12 0
Gold contents ...	120	160 0 0
	£130	£193 12 0
		130 0 0

Profit, treatment, and charges = £63 12 0 per ton.
= about one-third total value.

A London quotation of August 1916, shows that Shamrock ore containing 4% of bismuth is worth 3s. 6d. per lb. for bismuth contents, the gold being paid for at the rate of 82s. 6d. per oz. The treatment charge is £5 per ton and the ore must be delivered in London, the freight for which at present is £30 per ton.

With regard to undesirable constituents of bismuth ores and their effect on the price of the ores, we quote the following paragraph in Mr. Dunstan's report:

Arsenic is often associated with bismuth ores, and traces are generally present in crude metal. The removal of the impurity is said to be effected by subjecting the ore or metal to a dull red heat, at a temperature of 510-520° F. in a furnace under cover of charcoal. In pharmaceutical preparations this element must be eliminated, the British Pharmacopœia standard allowing not more than two parts in 1,000,000 in the carbonate and subnitrate. Tellurium is a very injurious impurity in bismuth, and the crystalline structure of the metal is completely changed if 0·05% is present. Antimony is separated from bismuth by roasting it at a temperature of 350° F., the two forming an alloy which floats on the surface of the charge, and which can be skimmed off. Copper can be removed from molten bismuth, provided oxidizable metals are first removed, by introducing bismuth sulphide. This reacts with the metallic copper to form a matte which comes to the surface of the charge. Lead is removed from molten bismuth in Pattinson pots, the lead-bismuth alloy remaining molten while the pure bismuth forms crystals, and as such is removed.

Flotation of Oxidized Ores.—The *Bulletin* of the American Institute of Mining Engineers for February contains a paper on flotation by Mr. J. M. Callow, of Salt Lake City. Part of this paper is devoted to replies to authors of previous papers, particularly those quoted in our issue of December last, and the remainder gives some notes on recent applications of flotation. We extract herewith some information relating to the plant at the Magma copper mine, at Superior, Arizona, used for the treatment of oxidized copper ore by sulphuretted hydrogen for the purpose of covering the ore with a film of sulphide, which makes the ore amenable to flotation. Here we may mention that we gave an outline of Ralston and Allen's researches in this direction in our issue of September last. Schwarz's United States patent 807,501 is the earliest to mention this method of floating oxides.

At the Magma mine there are several classes of ore, sulphide copper ores, ores preponderating in blende, and oxidized ore. The tailing of the copper sulphide flotation plant also contains oxidized ore as well as sulphide. When the treatment of the oxidized ore was first tried, the sulphuretted hydrogen was introduced through the bottom of an open vat in which was a mixing agitator. The loss of gas was too high, and its escape was obnoxious to the men. Subsequently the plant was reconstructed, and the gas was introduced into the suction of a centrifugal pump which carries the pulp from the crushing and oiling plant to the flotation cells. A blowing cell is interposed to remove any free gas before the pulp goes to the flotation cells. Mr. Callow finds that the oiling may be done before the sulphide-filming. The sulphuretted hydrogen is produced by distilling crude petroleum oil with sulphur in retorts, as the conditions favour this method as against the method by treating iron matte with sulphuric acid.

Fulton's Electric Zinc Furnace.—For some time Dr. C. H. Fulton, of Cleveland, Ohio, has been experimenting on the electric smelting of zinc ores. Dr. Fulton is known in this country for his writings on metallurgy. *Metallurgical and Chemical Engineering* for February 1 contains an account of his furnace and process, based on information disclosed in United States patent 1,213,180, issued January 23, 1917. In this furnace the charge itself is the resistor. The charge is made in the form of briquettes which preserve their form and volume during distillation. These are placed so as to form a continuous resistor between the electrodes. The heat is developed uniformly within the resistor without local overheating. The roasted or calcined ore is mixed with pulverized coke and finely-ground hard coal-tar pitch, in the proportions of 50 to 60%, 30 to 40%, and 10 to 20%. The mixture is heated to the melting point of the pitch, and made into briquettes of cylindrical shape in moulds, being subjected to a pressure of 500 lb. per square inch. The briquettes are pre-heated to drive off the volatile hydrocarbons, which would otherwise dilute the gases formed in the distilling furnace. This heating is done in a reducing atmosphere, the briquettes being embedded in finely crushed coke, at a temperature gradually rising from 400 to 600° C. This temperature may advantageously be raised to 650 or 700° C. in order to make the briquettes better conductors. The illustration shows (A) the distilling retort, and (B) the condenser. To insert the charge, the condenser is lowered as in Fig. 1; the retort is shown closed in Fig. 2. The briquettes are in contact with graphite electrodes at top and bottom. The zinc vapour fills the retort space and passes down through openings 20 into the condenser, which is kept at a temperature of from 650° at the top to 500° near the bottom by means of carbon resistors in the shell. The plates 19 and the walls 18 afford opportunity for condensing the zinc vapour, and the liquid zinc collects at the bottom.

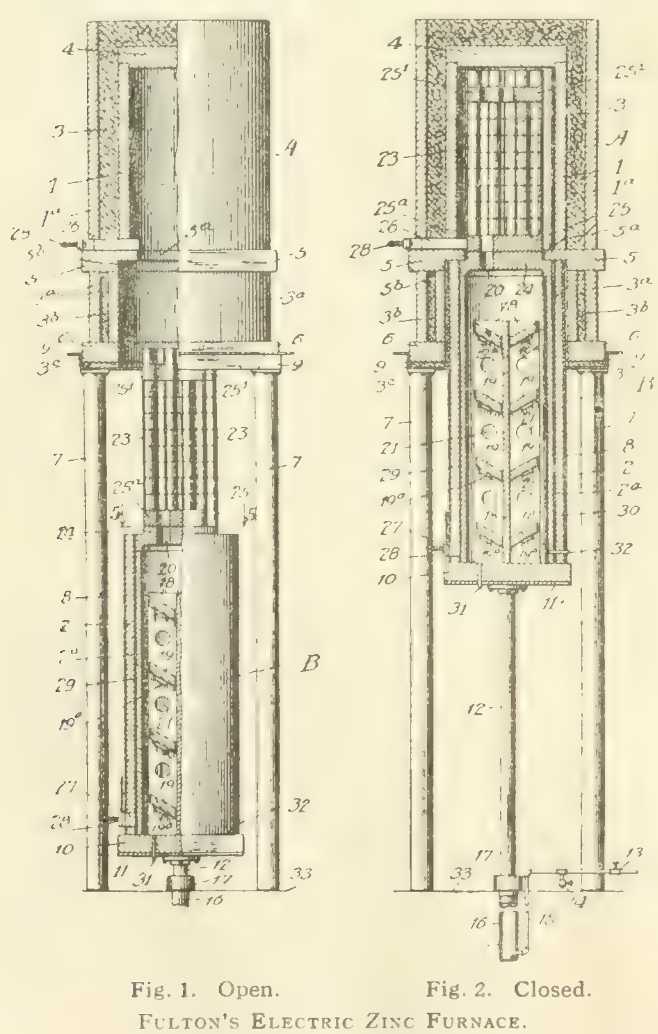


Fig. 1. Open. Fig. 2. Closed.

FULTON'S ELECTRIC ZINC FURNACE.

Electrolytic Zinc: Bibliography and Anaconda Practice.—The Canadian Mining Institute *Bulletin* for March contains a paper by Mr. E. P. Mathewson consisting of a historical bibliography relating to the production of zinc by the electrolysis of aqueous solutions. The items are in many cases given additional interest by notes and comments on the processes or proposals. Mr. Mathewson gives also some account of the investigations and the plant at Anaconda. The experimental plant working on a commercial scale had a capacity of 10 tons per day, and this was afterwards increased to 35 tons. The plant subsequently erected when the details had been worked out has a capacity of 160 to 175 tons per day. The first unit of this plant was started six months ago, two others in December, and the final two last month. During the course of the experiments and during the trials in the test plant the process originally proposed was much simplified. The process finally adopted consists essentially of the following steps: First careful roasting of the concentrate at temperatures not exceeding about 730° C.; then dissolving the zinc together with a little iron by means of spent electrolyte in Pachuca vats. A small amount of manganese dioxide is then added to effect the oxidation of the iron, which is then precipitated by means of powdered limestone, bringing down any arsenic or antimony that may be dissolved. These are separated in Oliver filters, and the residue sent to the blast-furnaces, while the filtrate, which contains nothing but zinc with a little cadmium and copper, is then treated with zinc dust and again filtered, the filtrate being the pure solution which is sent to the tank room. The anodes are pure lead and the cathodes pure aluminium. The deposition goes on for 48 hours only, when the zinc is stripped from the cathode sheets, and then melted into slabs. Mr. Mathewson refers in appreciative terms to the work done by Messrs. Laist and Frick at Anaconda.

The bibliography shows that electro-deposition of zinc is no new thing. The Siemens & Halske experts were early in the field, and the names of Hoepfner, Engelhardt, Huth, Isherwood, and, let us add, Ashcroft are well known. Japanese metallurgists attacked the problem about ten years ago, and, stimulated by war prices, have extended the work and now have three plants.

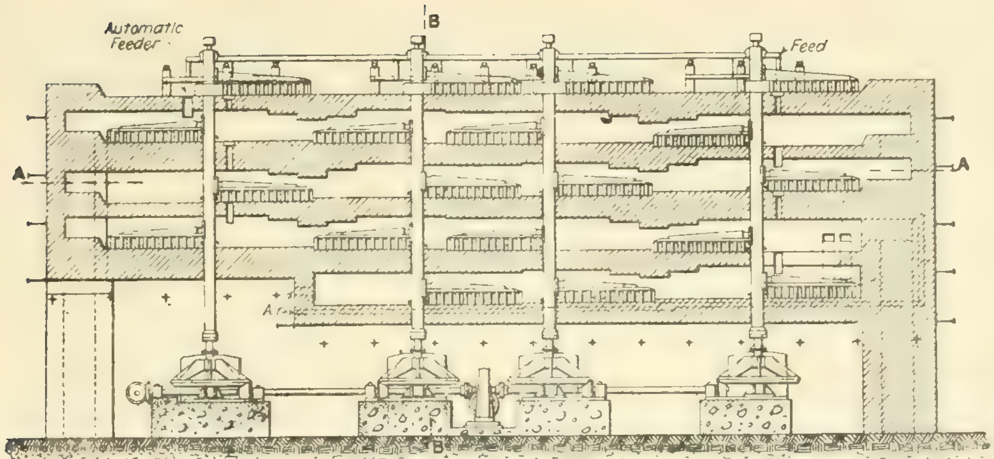


FIG. 1 Longitudinal Section

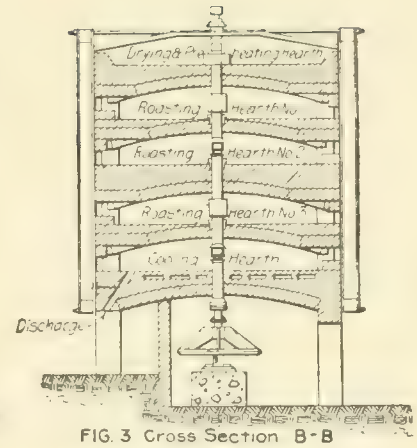


FIG. 3 Cross Section B-B

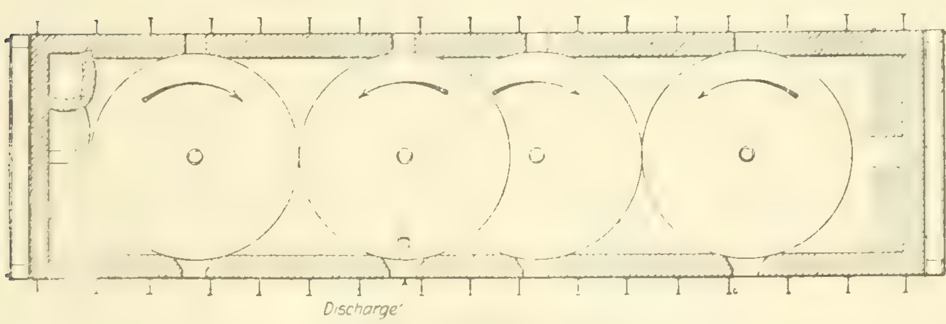


FIG 2 Horizontal Section A-A

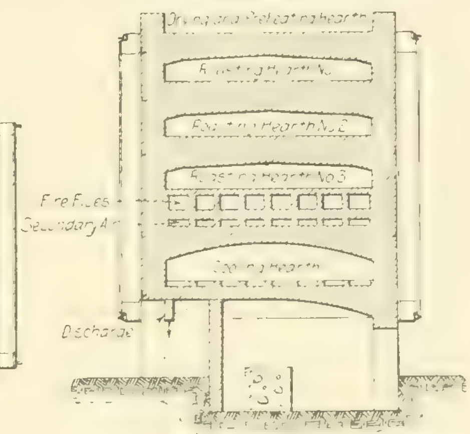


FIG 4 Cross Section trough Muffled Furnace

THE RIDGE ROASTING FURNACE.

The Ridge Roasting Furnace.—In the *Engineering and Mining Journal* for February 17, Mr. H. M. Ridge describes his roasting furnace. This furnace has been introduced lately in South Wales and elsewhere for roasting zinc concentrates and other purposes. Illustrations accompany the article. Fig. 1 shows a longitudinal section, Fig. 2 a hearth plan, and Fig. 3 a cross-section of the direct-fired furnace. The ore is fed continuously to the top hearth and is gradually dried by the heat from the top arch. Most of the ore treated carries lead, and unless it is dried gradually under continual stirring, lumps are formed which do not disintegrate in roasting. The dried and pre-heated ore is fed to the top roasting hearth and is rabbled along this hearth, and also the middle and bottom roasting hearths, and then drops to the cooling hearth to pre-heat the air required in the furnace. By cooling the ore before it leaves the furnace, heat units are saved and at the same time any tendency of the ore particles to stick together is overcome. The over-all length of the brickwork of the furnace is 56 ft. Flotation concentrate from Broken Hill is treated in this furnace with a reduction of the sulphur content to about $1\frac{1}{4}$ to $1\frac{1}{2}$%, with a claimed fuel consumption of under 8%. One furnace treats 12 to 14 long tons per day, with a power consumption of 7 to 8 hp. and a small amount of cooling water. Only one man per shift is required. Repairs on these furnaces have been small. On two furnaces during the last $2\frac{1}{2}$ years, only two arms were broken and had to be replaced. Of course the rabbles which are in contact with the hot ore are renewed, but this does not interfere with the regular working of the furnace. The cost of one of these furnaces before the war was £3,000 erected complete with electric motor, so that the initial outlay compared favourably with the older designs of mechanical furnaces.

Most of the Ridge furnaces are muffled, so that the sulphur fumes can be used for making acid. Fig. 4 shows a cross-section through the muffled furnace. Rather more brickwork is required for this furnace than for the others, but with inexperienced labour it is easier to supervise, because good stoking is not so essential as with the direct-fired furnace. The fire gases leave the furnace at a high temperature and pass through a recuperator to pre-heat part of the air going to the furnace, while the rest of the air is pre-heated by the hot ore. The ore is warmed up sufficiently on the drying hearth so that it ignites as soon as it enters the top roasting hearth; the sulphur fumes thus leave the furnace at a high temperature.

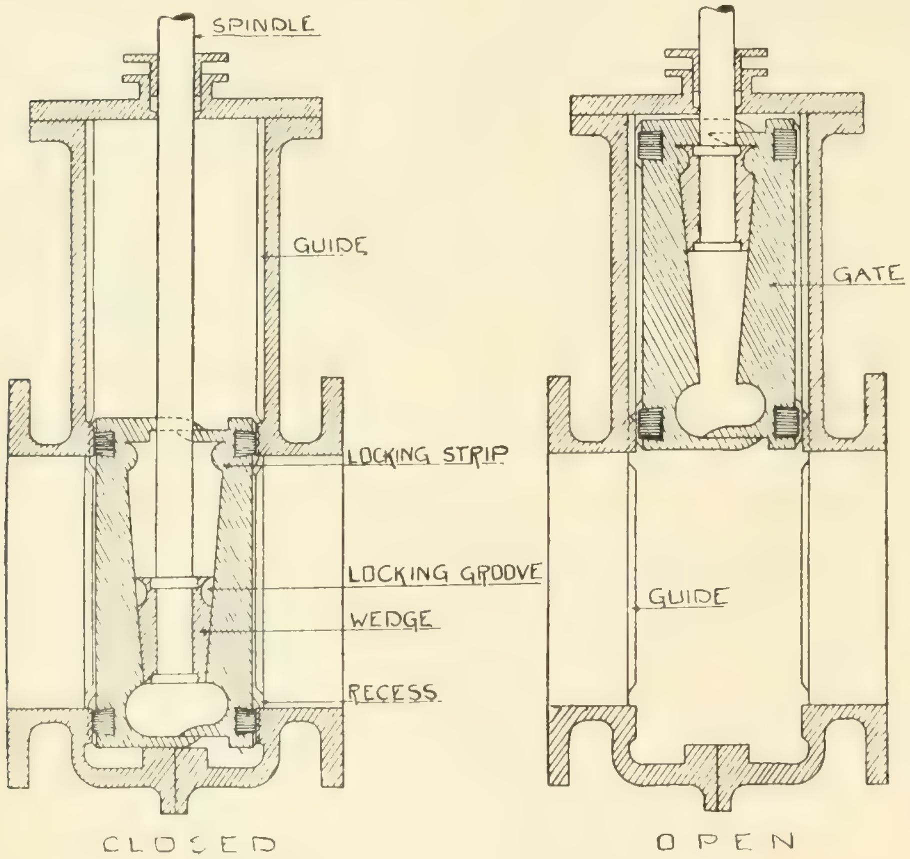
The mechanical details are simple. Each of the four shafts is made in one piece, and the arms are fixed to the shaft in such a way that they can be renewed easily when necessary. The driving gear is placed on a solid foundation away from the heat and is protected from the dust. The main driving wheels are independent of the shaft, which can be raised or lowered at will.

It was not expected to reduce the sulphur content further than is possible in the best hand furnaces, but this is accomplished on a wide variety of ores. One smelter had much trouble with a highly ferruginous blende; in the hand roasters the average sulphur was $3\frac{1}{4}$%, but in the mechanical furnace as low as $2\frac{1}{4}$% could be obtained without difficulty. On good ores the sulphur can easily be reduced to 0·7 and 0·6 per cent.

Sulphur in Petroleum and Shale-Oil.—At the meeting of the Institution of Petroleum Technologists held on March 20, Dr. F. Mollwo Perkin read a paper on sulphur in petroleum oils. As recently recorded in our pages, the high sulphur content in oils occurring at various places in the Empire such as in the English Kimmeridge Clays prevent the use of these resources.

Chemists are on the lookout for a process that will eliminate these large proportions of the obnoxious element. Dr. Perkin reviews the conditions under which the sulphur occurs, and discusses various proposals and methods. In conjunction with Messrs Lucas and Palmer, he has been developing a process in which ammonia is used at high temperatures and pressures. The reaction between the ammonia and the thio compound releases the sulphur as sulphuretted hydrogen. It is found also that this reaction will in some cases hydrogenize the compound, that is to say add atoms of hydrogen.

Valves for Slime Circuits.—In the *Monthly Journal* of the Chamber of Mines of West Australia, Mr. Thomas B. Stevens gives a review of many recent improvements in detail in vacuum-filtration practice at the West Australian mines. We extract herewith his description of a new valve for use in the pipes conveying the pulp.



SHAW'S VALVE FOR SLIME CIRCUITS.

In the early plants, considerable trouble was caused by wear of the gates and seats of the filling and emptying valves, especially when dealing with sandy pulp, such as is frequently met with in the so-called all-sliming process. Not only was the renewal of the valves a constant expense, but serious amounts of dissolved gold were often discharged with the residue, owing to the gold-bearing pulp leaking into the wash water. In closing the ordinary type of full-way valve, the gate slides over the seat so that any sand which has accumulated around the gate causes a powerful abrasive action, and it is only a short time before a small leak is developed, which is rapidly enlarged by the scouring action of the pulp. It follows, therefore, that a satisfactory valve must not even leak a small amount. A valve which is particularly suitable for this class of work has been introduced by Mr. Edward Shaw, of the Oroya Links mine, Kalgoorlie. Mr. Shaw has greatly reduced the possibility of wear and leakage by fitting the gate of the valve with a renewable fibrous wearing ring, so that no metal-to-metal joint is made; by means of an ingenious design of the closing wedge, he also makes it impossible for the gate to touch the seat until it is in the correct position for tightening. For the convenience of manufacture, the casing is made in two halves, which are flanged together. The gate is a double-seated one and in each half of it a groove of dove-tailed section is turned, into which the packing ring is fitted. The most satisfactory material for this ring has been found to be hard cotton hydraulic packing, which should be driven into the groove with the edges of the layers of cotton exposed. If put in with the layers flat, the outer plies of cotton are likely to peel off. The life of the rings is from six to twelve months, when used in a plant which puts through as many as twelve filter-charges a day. The gates are closed by a wedge, which is also made in two parts, and is carried on collars turned on the spindle. On each side of the upper part of the wedge a groove is cut, called a locking-groove, which fit over locking-strips which are cast inside the gates; these strips and grooves are important details in the satisfactory working of the valve.

The operation of the valve is as follows. When starting to open, the spindle and wedge are raised and the gates are released from the seats, after which the wedge rides over the locking strips. It is not until the wedge touches the top of the inside of the gates that they start to rise, and as soon as they do start they are at the same time forced inwards by the guides in the trunk, which are flush with the seat, so that any rubbing action on the packed face is prevented. Raised flats are provided on the corner of each gate to ride on the guide strips. On starting to close, the gates will be up in the trunk and locked to the wedge by means of the locking strips, so that the wedge and gates descend together; it is not until the correct position for tightening the gates is reached that the raised flats on them can fall into recesses provided in the guide strips so as to free the wedge and allow it to fall relative to the gates so as to expand them. To give satisfactory service, valves of this kind must be set vertically, as otherwise the gates will bind in the guides. At the same time, it must be remembered that all kinds of gate valves are preferably set in this position, and in the design of pipe arrangements thought given to this detail is amply repaid by the subsequent ease of operation and freedom from repairs. That the Shaw type of valve is a commercial success, is proved by the fact that in one plant over thirty of them varying in diameter from 4 to 12 inches have been in constant use for over two years, and have needed no renewals except that of the packing rings.

The Whiting Hoist.—The February *Journal* of the South African Institution of Engineers contains a paper by Messrs. B. Gray and J. Whitehouse entitled "Recent Development of the Whiting Hoist as applied to Deep Mining." Messrs. Fraser & Chalmers have made several hoists of this type for the Rand, notably at Village Deep and City Deep. The authors of this paper describe their experience with the hoist at

Village Deep vertical shaft, winding from 4,100 ft. For the benefit of non-technical readers we may say that in the Whiting hoist the rope is passed round two driving reels, and its two ends go over the headgear sheaves and down the shaft, carrying each a skip. The two skips are connected by a tail-rope passing under a weighted sheave. The rope is usually passed round the driving sheaves three times so as to secure a good grip. The authors found, in their experience, that many difficulties were caused by this multiplication of turns, owing to the great strain on the reel shafts and on the bearings. They proceeded to investigate whether two turns or even one turn could be used effectively, and finally they found that one turn is enough if certain modifications are made and precautions taken. These details are discussed in the paper. Unfortunately we have not space for adequate quotation or for reproduction of the drawings. As an important contribution to the subject of winding from great depths, the paper deserves full study.

St. Ives Mines. — At the meeting of the Cornish Institute of Engineers held on March 10, Mr. F. C. Cann read a paper on the mines, lodes, and minerals of the Stennack Valley, St. Ives. These mines are to the south and west of St. Ives, and among them are the Trenwith, Giew, St. Ives Consols, Rosewall Hill, and others, which were worked from 1910 to 1916 by the St. Ives Consolidated Mines Limited. Trenwith yields pitchblende, and a subsidiary company treated it for radium. The Giew is a promising property, and the dressing plant is of excellent design. The old controllers of this group did not make a success. In our March issue reference was made to the revival of operations under new auspices. In his paper, Mr. Cann gives an outline of the geology of the district and an account of the vein systems.

Coro Coro and Porco.—Two American geologists have recently made an extended tour through the mineral regions of South America, J. T. Singewald, of Johns Hopkins, and B. L. Miller, of Lehigh University. They have written many papers for the American press and societies. We draw attention to a description of the Coro Coro copper mines in Bolivia appearing in the *Engineering and Mining Journal* for January 27, and an account of the Porco tin mines in Bolivia in the issue of February 24. Both these properties are controlled by companies registered in England.

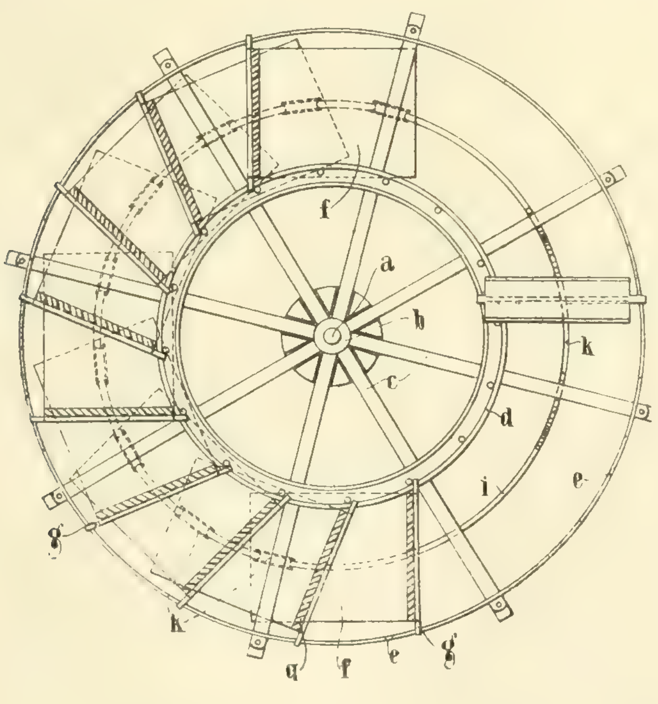
RECENT PATENTS

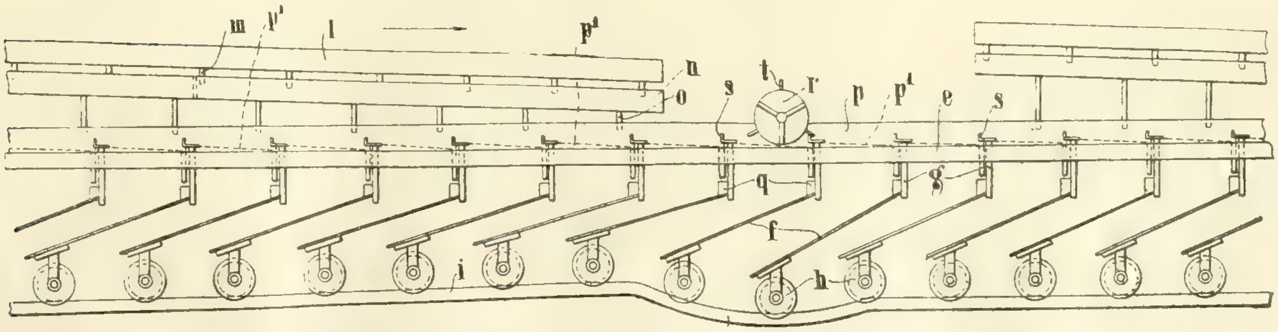
1,738 of 1916 (100,069). Patent Corporation, Liverpool. Forming lead monoxide by aspirating molten lead with air; this monoxide is to be used in making white lead by the dry process.

2,459 of 1916 (104,025). G. H. Whiteley, York, Pennsylvania. A dental alloy devised as a substitute for pure platinum, consisting of 15 to 20% platinum, 30 to 35% palladium, and 45 to 55% gold.

10,407 of 1916 (101,029). F. A. Mitchell, Reading, Massachusetts. Production of lead arsenate by treating lead and white arsenic with nitric acid as oxidizing agent, the nitric acid being afterward recovered.

2,204 of 1916 (103,858). M. T. Taylor, East Pool, Camborne. This invention relates to rotating concentrating tables intended for tin slime, and the object is to increase the surface available in a given area and to provide means for varying the slope of the surface according to the material treated. The illustrations show a rotating frame consisting of a boss *b*, radiating arms *c*, and circular rings *d* and *e*. From these rings are suspended planes *f*, hung from adjustable hangers *g* and resting on runners *h* which travel on a circular rail *i*. The pulp to be concentrated is fed by the stationary launder *n*, together with water from the launder *m*, to a circular launder *p* travelling with the frame. The pulp is distributed from *p* to trays *q* from whence it passes down the planes *f*. The launder *p* is formed of inclined sections marked p^1 between each plane, so as to properly distribute the pulp. A depression in the track *i* causes a steepening of the planes and provides opportunity for washing off the adhering concentrate. At this point also there is a drum *r* containing water which assists the wash-off. The drum is divided into compartments, which are successively filled and emptied by the projections *s* engaging with projections *t* on the shaft of the drum.





Plan and Developed Elevation of Taylor's Concentrating Table.

3,176 of 1916 (100,301). A. S. RAMAGE, Detroit, U.S.A. Making sulphate of lead by roasting galena in a muffle so producing a mixture of sulphide, sulphate, and oxide, then treating the mixture with nitric acid so as to convert the sulphide to sulphate and the oxide to nitrate, then using the nitrous fumes to react on the sulphurous fumes to form sulphuric acid, and treating the mixture with this acid to form pure sulphate of lead.

10,154 of 1916 (101,208). F. C. FRARY, Niagara Falls, and S. N. TEMPLE, St. Paul. Use of barium for hardening lead instead of antimony.

10,155 of 1916 (101,209). F. C. FRARY, Niagara Falls, and S. N. TEMPLE, St. Paul. Using magnesium for hardening lead instead of antimony.

5,132 and 5,429 of 1916 (104,064). G. E. HEYL, London. A continuous process for producing ferro-alloys, in which the smelting mixture is passed into the furnace in the form of a ribbon.

11,413 of 1916 (104,115). R. DEMPSTER, Manchester. In the production of hydrogen by alternately acting on iron oxide in the form of spathic iron ore by reducing and oxidizing gases, means for preventing the undue breaking of the ore as it is charged into the retorts.

10,613 of 1916 (101,211). S. HULDT, Stockholm, Sweden. Refining zinc by volatilization in a continuous electric radiating furnace.

1,691 of 1916 (103,689). J. P. LLEWELLYN, Manchester. Treating waste nitre cake, that is, acid sulphate of soda, with iron pyrites thus producing sulphate of soda, sulphurous acid, and sulphur.

3,083 of 1916 (103,716). WEAVER CO., Milwaukee, Wisconsin. Treating aluminium silicates with gaseous chlorine to form chloride of aluminium and chloride of silicon, and subsequently producing aluminium and silicon.

3,345 of 1916 (103,722). BADISCHE ANILIN & SODA FABRIK, Ludwigshafen-on-Rhine. A new non-hygroscopic fertilizer, being a double compound of calcium nitrate and urea.

452 of 1916 (103,836). J. HALL, Birmingham. A continuous furnace for recovering tin and solder from old tin cans.

2,407 of 1916 (103,877). H. E. MACADAM and H. WALKER, London. In the process of making sulphuric acid by injecting a solution of nitrate of soda into the chambers instead of nitrous vapours, improvements whereby sulphate of soda does not become mixed with the acid formed.

NEW BOOKS

Explosives : Vol. 1, History and Manufacture. By Arthur Marshall. Revised Edition. Cloth, quarto, 400 pages, illustrated. Price of Vols. 1 and 2, not sold separately, 63s. net. London : J. & A. Churchill.

In our issue of May 1915, we gave a review of the first edition of this important work on explosives. The book had been prepared before the war, and for that reason it did not touch on certain aspects of the explosive problem that were prominently before the community at the time of its publication. In spite of this fact, the book proved of immense value to the multitude of engineers and chemists who undertook unfamiliar work when the vast expansion of exploives manufacture was undertaken in this country. It was only natural that the author felt encouraged to prepare a new edition, which contains additional information on modern high explosives and propellants. The new edition is being issued in two parts. The first volume now published deals with the history of explosives, gunpowder, the production of nitric acid, the nitrating of cellulose, the nitrating of glycerine, the nitrating of the benzene or aromatic series, the manufacture of smokeless powders, and the manufacture of blasting powders. The most important addition is that relating to the manufacture of the nitration products of the aromatic series, benzene, toluene, phenol, aniline, etc. Until the war, the high explosives for shells did not loom large in the scientific world or in the popular view, though picric acid, the nitration product of phenol or carbolic acid, had been made in England under the name of lyddite and in France as melinite. In the first edition of this work, these compounds did not receive much notice. This omission has now been partly rectified, though the added matter is not extensive. Another branch of the subject on which additional imformation is given is the production of nitric acid from the air, but here again only the outlines are indicated. When the second volume of the new edition is published we shall be able to give a more comprehensive review.

Compressed-Air Practice in Mining. By David Penman. Cloth, octavo, 220 pages, illustrated ; price 5s. net. London : Charles Griffin & Co., Ld.

This work is intended by the author for mining students and for engineers in practice. Its mathematics are, however, too deep for students who have had only an elementary school education, as the calculus is used. Three chapters are devoted to the theory of air compression and expansion, this part of the book being good and serviceable. The chapter, too, on the transmission of compressed air is very useful.

A large part of the work is taken up with the description of modern compressors, coal-cutting machines, conveyors, rock-drills, etc. This portion will be useful to students. There are numerous illustrations and diagrams, many of which are good, but a few of the illustrations are marred by incorrect details. The book is one that mining engineers will be glad to have on their shelves.

HUMPHREY M. MORGANS.

Industrial and Manufucturing Chemistry : Inorganic. Vol. 1. By Geoffrey Martin, Ph.D., D.Sc., assisted by many chemists and engineers. Large octavo, cloth, 500 pages, illustrated ; price 25s. net. London : Crosby Lockwood & Son.

During the last year or so we have reviewed a number of manuals of industrial chemistry written by or prepared under the general guidance of Dr. Geoffrey Martin, and we have expressed our general approval of his work. The present volume is the first of two, dealing with some of the subjects already covered by the handbooks and also with a great variety of other subjects that are less extensive in range. The volume is really a condensed encyclopedia or extended dictionary of inorganic industrial chemistry, and as such constitutes an excellent index of the applications and treatments of mineral products. The following are some of the subjects covered : fuels and furnaces, coke ovens, surface combustion, pyrometry, refrigerating machinery, liquified gases, production of oxygen, nitrogen, hydrogen, producer gas, carbonic acid, and ozone, the technology of water, artificial mineral waters, sulphur, sulphuric acid, salt, hydrochloric acid, soda and its compounds, potash salts, chlorine, iodine, hydrofluoric acid, nitric acid and nitrates, ammonia, cyanide, cyanamide, etc. A second volume is now in the press.

The Banket. By Professor R. B. Young. Cloth, octavo, 130 pages, illustrated; price 8s. 6d. net. London: Gurney & Jackson.

A review of this book on the Rand Conglomerates, by the professor of geology in the South African School of Mines, will appear in our next issue.

A Treatise on Mine Surveying. By Bennett H. Brough, revised and enlarged by Harry Dean. Cloth, octavo, 500 pages, illustrated; price 7s. 6d. net.

A review of this book is in preparation. In the meantime we may say that Mr. Dean, the reviser, who is lecturer on surveying in the University of Durham, has made several important additions to and rearrangements in Brough's Surveying.

Official Year-Book of the Scientific and Learned Societies of Great Britain and Ireland. Cloth, octavo, 340 pages; price 7s. 6d. net. London: Charles Griffin & Co., Ltd.

This useful year-book contains information relating to scientific and learned societies, their councils and staffs, and scopes of interest. A record is also given of the papers read during the year.

TECHNICAL PAPERS

British

Colliery Guardian. — *March 2:* Cementation at Llay Hall Colliery Shafts, P. Sidebottom; the Gainey Visual Indicator for Winding Plant. *March 16:* Naval Coaling Equipment of the United States, F. J. Warden-Stevens. *March 23:* Explosion at the Reserve Coal Mine, British Columbia, James Ashworth.

The Engineer.—*March 9:* What Industry owes to Science; Refractory Materials, Glass; The Scottish Shale-Oil Industry [continued March 23].

Engineering.—*March 2:* Telpher Installation at the Dalmarnock Gas Works, Glasgow, G. F. Zimmer. *March 9:* Germany's Coal Deposits. *March 23:* Pontoon for Transport across the Zambesi River, Rhodesia. *March 30:* Kermode's Oil-fired Marine Boiler.

Geological Magazine. — *March:* Classification of Igneous Rocks, Arthur Holmes.

Institute of Metals.—*March 21:* Aluminium Production by Electrolysis, R. Seligman; Metal Melting at the Royal Mint, W. J. Hocking; Coal Gas for Melting Alloys, G. B. Brook; Coal Gas Melting of Brass and Copper, H. M. Thornton & H. Hartley; Crude-Oil Melting Furnace, H. S. Primrose; Annealing of Nickel Silver, F. C. Thompson; Electric Resistance Melting Furnace, H. C. Greenwood; High-Pressure Gas Melting, C. M. Walter

Institution of Civil Engineers.—*April 3:* Water Supply at Coolgardie and in the Interior of Western Australia, P. V. O'Brien and J. Parr.

Iron & Coal Trades Review.—*March 2:* Iron and Steel Syndicates in Russia. *March 9:* Electric Signalling in Mines, describing the Davis-Railing, Davis. Davis-Fryer, Gent, Sterling, and Thornton methods. *March 16:* New Shafts and Hauling Plant for the Whitehaven Colliery, Cumberland. *March 23:* Refrigeration in Relation to Mining, A. D. Brydon.

Midland Institute of Mining, Civil, & Mechanical Engineers.—*March 8:* The Cementation Process for Mines, T. Blandford.

Royal Institution of Great Britain.—*March 13, 20, and 27:* Geological War Problems, Professor J. W. Gregory.

Society of Chemical Industry Journal.—*February 28:* Brown Coal Distillation Industry of Germany, D. R. Steuart; Need for a National Fuel and Power Policy, Professor Henry E. Armstrong; Detection of Hydrocyanic Acid, G. W. Anderson. *March 15:* Drawing of Metals into Wire, A. T. Adam; Artificial Fertilizers, their Use and Prospects, Dr. E. J. Russell; Basic Slag, as a Fertilizer, Professors D. A. Gilchrist and Henry Louis; Estimation of Small Quantities of Cobalt.

Colonial

Canadian Mining Institute Bulletin. — *March:* Notes on the Occurrence of Native Copper in Arctic Canada, J. J. O'Neill; Bibliography of Electrolytic Zinc, E. P. Mathewson.

Canadian Mining Journal.—*February 15:* Progress of Copper Mining in British Columbia, E. Jacobs. *March 1:* Metallurgy at Cobalt during 1916, R. B. Watson; Gold and Silver Mining in Northern Ontario, Retrospective and Prospective, H. L. Gibson.

Queensland Government Mining Journal.—*January:* Resources of Bismuth, its production and uses, B. Dunstan; Coal at Oxley Creek, Hughenden District, J. H. Reid.

South African Institution of Engineers Journal. *February 17:* Recent Developments of the Whiting Hoist as applied to Deep Mining, B. Gray and J. Whitehouse.

South African Mining Journal.—*February:* The Orange River Diamond Fields, Dr. P. A. Wagner; Coal-shipping Plant at Durban, built by Fraser & Chalmers.

Foreign.

American Institute of Mining Engineers Bulletin.—*March:* Methods of Determining the Capacities of Slime-Thickening Tanks, R. T. Mishler; Exploration of Metalliferous Deposits, W. H. Emmons; Tayeh Iron Ore Deposits, China, C. Y. Wang.

Economic Geology.—*January:* Continued Discussion as to the Genesis of the Engels Copper Deposits, California, L. C. Graton and D. H. McLaughlin; Appalachian Oilfield Brine, G. B. Richardson.

Engineering and Mining Journal.—*February 17:* Bag-house of the St. Joseph Lead Co., Missouri, S. P. Lindau; Wetherbee Iron Ore Concentrator at La Rue Mine, Minnesota, S. A. Mahon; Flin-Flon Lake Copper District, J. W. Callinan; Ridge Roasting Furnace for Zinc Ores. *February 24:* Porco Tin Mining District, Bolivia, J. T. Singewald and B. L. Miller; Rork-Sandberg Flotation Machine, G. C. Westby. *March 3:* Depreciation and Measurement of Expired Outlay on Plant, E. A. Erickson [continued March 17]; Santa Ana, a Pocket Gold Mine in Chile, E. David Pope; Lubrication of Rock-Drills, C. C. Phelps; Refinement in Chemical Analysis. *March 10:* Metal Mining in Russia, S. H. Ball and B. Low; The Tacoma Smelter's New Schedule. *March 17:* History of the Divining Rod; Tube-Mill Practice in Rhodesia, A. W. Allen.

Franklin Institute Journal.—*March:* Organic Nitrogen Compounds of Soils and Fertilizers, E. C. Lathrop.

Metallurgical and Chemical Engineering.—*February 15:* Drying Air for Furnaces, Carl Hering; Effect of Centrifugal Force on Colloidal Solutions, E. E. Ayres; Carbonization of Seaweed for the Recovery of Potash, J. W. Turrentine. *March 1:* Nitrate Industry of Chile, I. B. Hobsbawn; Determination of Zinc, J. H. Hastings; Hydro-electric Power in Chemistry and Metallurgy in France, C. O. Mailloux [continued March 15]; Bibliography of Alloys, C. Estes. *March 15:* Thiogen Process for Removing

Sulphur Fumes, S. W. Young; Current Density in Copper Refining, L. Addicks; Fixation of Nitrogen as Cyanide, J. E. Bucher; Salt Manufacture by Solar Evaporation of Sea Water, L. A. Palmer; Analysis of Nickel-Chromium Alloys, E. D. Koepping; The Cottrell Fume-settling Process in Practice, L. Bradley; Ball-milling in the Marcy Mill, F. E. Marcy; The K & K Flotation Machine.

Mining and Scientific Press.—*February 17:* Fine Grinding at Inspiration, David Cole; Metallurgical Problems of the Rand, H. F. Bain; Origin and Geo-Chemistry of Magnesite, S. H. Dolbear. *March 3:* Modern Gold-Mining in Ancient Egypt, E. H. S. Sampson; West American Metallurgy, Visitor from Abroad. *March 10:* Iron and Manganese in Brazil, F. Lynwood Garrison. Copies of the issues of February 10 and 24 have not arrived in this country; the former were in the Laconia.

COMPANY REPORTS

South Crofty.—This company was formed in 1906 by the Allen-Meyerstein group to acquire the tin-wolfram-arsenic mine of this name near Camborne, Cornwall. Modern methods of mining and dressing were introduced, and in spite of the fact that the ore is complex and of low grade, dividends have been paid continuously since 1909. Josiah Paull is manager. The report for the year 1916 shows that 71,706 tons of ore was raised, and that the yield was 607 tons of black tin, 95 tons of wolfram, and 783 tons of white arsenic. The amount of ore treated was practically the same as in 1915; the yields of black tin and wolfram were slightly less, but the output of arsenic was 120 tons greater. The receipts from the sale of black tin were £63,708, from wolfram £14,772, and from arsenic £24,391, the total being £102,872, as compared with £82,550 the year before. The receipts per ton were 28s. 9d. as compared with 23s. 5d. The net profit, after allowing for depreciation and income tax, was £16,703, and £16,250 has been paid as dividend, being at the rate of 32½%. Development continues to disclose ore of comparatively low grade, even in the shallow ground in Cook's section. Cross-cuts are being driven to intersect the continuation of the Rogers lode, which has given such remarkable assays in the adjoining East Pool mine.

Grenville United Mines.—This company was formed under limited liability in 1906 to acquire a tin mine south of Camborne, Cornwall, which had been for many years previously worked on the cost-book system. Satisfactory profits were made at first, but for the last three years or so, the ore has been of too low a grade to pay and losses have been incurred. The report for the six months ended December 31 last shows that 22,207 tons of ore was raised and treated, and that the yield was 260 tons of black tin, being an extraction of 26¼ lb. per ton. These figures are not greatly different from those of the previous half-year, though the yield per ton is slightly down. The produce sold for £24,219, and the cost was £34,138, so that the loss was considerable. Fortunately the company has a substantial reserve fund. The costs at this mine are necessarily high owing to the amount of pumping to be done. The present developments are reported to be rather more encouraging.

Cornish Wolfram Mines.—This company was formed in January 1916 to acquire from the Continuous Reaction Company Ld. the lease of the Park-an-Chy wolfram mines, east of Redruth, Cornwall. The property was worked in earlier days for copper and tin, but the wolfram was left behind. A few years ago the mines were partly reopened, but the venture was not continued. The present company was formed by people interested in the production of ferro-tungsten, and after reopening the old workings they were able to prove to the experts of the Munitions Department that capital judiciously expended would secure a substantial output of wolfram concentrate. The Government therefore advanced £10,000 on loan for the continuance of operations. A. Spencer Cragoe is the consulting engineer and manager. His report describes the work done in reopening the mine. He estimates the proved ore at 15,000 tons having a recoverable content of 1% wolfram concentrate of 65% WO_3. The necessary mining plant has been erected, and a concentrate having a capacity of 1,600 tons per month will be ready shortly.

Gopeng Consolidated.—This company was formed in 1912 as a consolidation of the Gopeng and New Gopeng, two companies belonging to the Wickett group at Redruth. The properties consist of tin-gravel mines in the Kinta district of Perak, Federated Malay States. The consolidation was arranged for the purpose of facilitating the financing of a plan for providing a new water-supply from the Kampur river, conjointly with the Kinta Tin Company. The report for the year ended September 30 last shows that 2,212,800 cubic yards of ground was treated, and that the yield of tin concentrate was 1,084 tons, selling for £110,451. During the previous year the yield was 681 tons and the receipts £61,702. The working profit for the year was £87,742. In addition, £2,733 was received as the share in the profit on the Ulu Gopeng property. Out of the profit, £20,384 has been written off the capital account in connection with the new pipe-line, and £8,000 has been placed to reserve. The shareholders received £59,365, being at the rate of 15%. The average yield per yard was 1·09 lb., and the working cost was 3·36d. per yard.

Tekka-Taiping.—This company was formed in 1913 as a subsidiary of the Tekka for the purpose of acquiring a tin-gravel property at Taiping, in the Larut district of Perak, Federated Malay States. James Wickett, of Redruth, is chairman, Osborne & Chappel are the general managers, and T. R. A. Windeatt is manager. Operations were started with a suction dredge, but subsequently bucket-dredging was adopted. The report for the year ended October 30 last shows that the suction dredge was in operation until the end of May, the yield being 129 tons of tin concentrate, and that the bucket-dredge, which started in September 1915, treated 938,300 cubic yards of ground for a yield of 540 tons of tin concentrate. The accounts show an income of £69,606, derived from the sale of 669 tons of tin concentrate, and a profit of £48,272. Out of this profit £8,679 was written off the suction-dredge account and £5,978 was allowed for depreciation of the bucket-dredge. The shareholders received £12,991, being at the rate of 20%. The returns from the bucket-dredge show a yield of 1·29 lb. per yard and a working cost of 3·72d. per yard.

Pengkalen.—This company was formed in 1907 by James Wickett, of Redruth, to acquire a tin-gravel property at Lahat, Perak, Federated Malay States. Operations have not proved as profitable as expected, though the yield by suction-dredging was fairly satisfactory. The fall in the price of tin on the outbreak of war caused a suspension of work. Dredging was resumed in July 1915. Part of the property was then let to tributers, and electric power was sold to other companies. The report for the year ended September 30 shows that 101 tons of tin concentrate was won by suction-dredging, selling for £10,421. Sales of power brought an income of £6,352, and £5,242 was received from tributers. The profit for the year was £10,127, out of which £4,000 has been written off for depreciation of plant, and £3,500 has been paid as dividend, being 12½% on 10,000 preference shares, and 2½% on 90,000 ordinary shares.

Mysore Gold.—This company was formed in 1880 by John Taylor & Sons to acquire old workings in the Kolar district of Mysore, Southern India. Dividends were first paid in 1886, and from then until the end of 1916 the output of gold has been £17,897,000, obtained from 4,831,000 tons of ore, and the dividends have totalled £8,390,344. The prosperity has been continuous, without any anxious moments until about a year ago, when the developments in depth began to disclose ore of a grade which could not be compensated by an increased scale of operations. The report for the year 1916 shows that 305,845 tons of ore was raised and milled, yielding by amalgamation 164,145 oz. of gold bullion; in addition 239,877 tons of sand tailing yielded 26,724 oz. of bullion and 193,748 tons of slime yielded 25,650 oz. The total yield was equivalent to 197,245 oz., realizing £836,743. Part of the yield from tailing and slime came from accumulations. The yield the year before was £880,167 from practically the same amount of ore, tailing, and slime. The working cost was £348,192. In addition £48,686 was paid as royalty, £56,200 was allocated to income tax, £19,000 was allowed for depreciation, and £98,023 was charged against the revenue account for the year for expenditure on tube-mills and re-treatment plant. The dividends absorbed £289,750, being at the rate of 95%, as compared with 110% for 1915. This is the first time since 1896 that the rate has been less than 100%. The development has been restricted by shortage of explosives and labour, but the tonnage of the reserve has been maintained at just over 1,000,000 tons. R. H. P. Bullen, the superintendent, reports that the outlook is more cheerful than a year ago. In particular he mentions that No. 2 lode in McTaggart's section has opened up well at the 33rd and 34th levels and has been proved to be payable 700 ft. below, where it is intersected by the vertical shaft; also that the bottom levels in Ribblesdale's sections are doing much better than a year ago.

Nundydroog. — This company belongs to John Taylor & Sons' group operating gold mines in the Kolar district, Mysore State, India. Milling started in 1882, and dividends have been paid since 1888. The report for the year 1916 shows that 98,000 tons of ore was treated for a yield of 74,930 oz. of gold bullion by amalgamation. In addition, 87,766 tons of current and accumulated tailing and 85,388 tons of slime were treated by cyanide for a yield of 16,018 oz. of bullion. The gold sold for £340,786, and the working profit was £154,569. Out of the profit £28,348 was spent on new plant and buildings and £10,290 on the new circular shaft, while £10,200 has been allocated to income tax. The shareholders received £99,050 (less income tax), being at the rate of 35%. As compared with the previous year, the income was £18,751 higher, the working profit £10,674 higher, and the dividend rate was the same. The gold output was the highest on record. The developments at various points have given good results during the year, and the reserve has been slightly increased to 217,300 tons, in spite of curtailment of work owing to scarcity of explosives.

Jibutil (Anantapur) Gold Mines.—This company was formed in 1911 by John Taylor & Sons to work a gold mine in the Anantapur district, Madras Presidency, India. Additional capital was raised in 1912 and 1913 to provide plant and to expand the scale of operations. Further funds have been desirable for some time, but the occasion is not suitable for the issue of new capital. The policy is to limit development to the funds available from the current output. The report for the year ended September 30 shows that 35,700 tons of ore was treated for a yield of 9,171 oz. worth £38,671, as compared with 29,590 tons, 9,035 oz., and £38,285 tons the year before. It will be seen that the yield per ton has decreased, and is not much more than £1. The working cost has been kept to this level, being 3s. 4d. less than the year before, due to curtailment of development. W. Stonor, the superintendent, estimates the reserve at 24,300 tons averaging over 6 dwt., and 14,000 tons of lower grade ore that might give a profit under certain circumstances. The most hopeful point is in the 1,000 ft. level at the South shaft, where the ore shoot averages 13 dwt. over 4 ft., for a length of 60 ft. The 1,100 ft. level is now being opened.

Sudan Gold Field.—This company was formed in 1904 by John Taylor & Sons to acquire prospecting licences in the Sudan, between the 20th and 22nd parallels of latitude. Eventually operations were centred on the Om Nabardi property. Additional capital was raised in 1908, and the first dividend was paid in 1914. The report for the year 1916 shows that 26,297 tons of ore was milled for a yield of 14,180 oz. of gold bullion by amalgamation, and that 18,840 tons of tailing was cyanided for a yield of 1,438 oz. of bullion. The total gold realized £54,521, and the profit was £19,073. Out of the profit, £3,879 has been written off, or allowed for necessary expenditure, and £8,486 has been placed provisionally for excess profits duty. The shareholders received £6,387, subject to income tax, being at the rate of 10%. The new 10-stamp mill was started in June, and the monthly capacity thereby raised from 1,500 to 3,000 tons. Owing to scarcity of labour and lack of materials for construction, the slime plant has not yet been completed. The ore reserve is estimated at 60,193 tons. An extended campaign of development will be undertaken during the current year. With the increased plant, the costs are reduced sufficiently to make it possible to treat ore of average lower grade.

Cordoba Copper.—This company was formed by John Taylor & Sons in 1908 as a consolidation of the Cerro Muriano and North Cerro Muriano companies, operating copper mines in the south of Spain, 10 miles northeast of the city of Cordoba. Dividends were paid in 1912 and 1913, and another has just been declared. Since the latter year, the grade of the ore has diminished, and the amount of copper produced has been much smaller. Owing to the presence of calcite it has not been possible to apply any flotation process employing acid, and instead the Murex magnetic process has been adopted for the treatment of middlings and slime. The report for the year 1916 shows that 95,949 tons of ore was raised, and after the rejection of waste, 84,800 tons averaging 2·47% copper was sent for treatment. This average compared with 2·77% the year before. Only a small amount of smelting ore is now picked before concentration. The yield of blister copper was 1,746 tons, which was practically the same as that for the previous year. The high price ruling for copper brought a bigger income, £203,338, as compared with £132,302 the year before. The working expenses were higher, being £162,884, as compared with £122,226. This advance was due to several causes: the decrease in the amount of direct-smelting ore, the greater amount of pumping done, and the repairs to buildings which were damaged by the storms early in the year. In addition to the working cost, £6,064 was paid as income tax, £8,000 was written off for depreciation of plant, and £4,940 was written off the expenditure in testing the San Rafael coal mine, a property which did not come up to expectations. The shareholders received £20,000, being at the rate of 10%. The installation of an improved Murex plant has recently increased the percentage of recovery. Development was hindered by the unusual inflow of water. Additional pumps and also winding engines are on order for continuing operations in depth. The outlook as regards ore reserves is now much better than it was eighteen months ago. The estimated figures are 142,914 tons averaging 2·39%, an increase of 8,625 tons and decrease of 0·25% as compared with those a year ago.

Esperanza Copper & Sulphur.—This company was formed in 1906 to acquire the Esperanza, Forzosa, and Angostura pyrite mines, in Huelva province, southern Spain. G. Mure Ritchie is chairman, and T. D. Lawther is managing director. Dividends have been paid for the years 1908 to 1912 and 1916. The report for the year 1916 shows that 46,265 tons of ore was raised from the Angostura, and 62,496 tons from the Esperanza and Forzosa, in both cases the amounts being greater than during 1915. The shipments from Huelva were 96,356 tons, and the copper precipitate produced was 127 tons. The accounts show a profit of £51,029, which added to the balance brought in made a disposable balance of £87,500. Out of this £46,614 has been applied to the redemption of the remaining outstanding debentures, and £35,000 has been distributed as dividend, being at the rate of 10%. Developments at the mines have continued favourable. The reserve at Angostura is estimated at 231,000 tons, and at Esperanza and Forzosa 507,000 tons.

Le Roi No. 2.—This company was formed in 1900 by the late Whitaker Wright to acquire the Josie, Annie, Poorman, and other gold-copper mines at Rossland, British Columbia. After the collapse the next year, Lord Ernest Hamilton and his friends took control and placed the management with Alexander Hill & Stewart. In their hands fairly regular profits have been made, and had it not been for the legacy of over-capitalization the rate of dividends would have been satisfactory. The properties adjoin the Le Roi, War Eagle, and Centre Star mines, owned by the Consolidated Mining & Smelting Company of Canada. The report for the year ended September 30 shows that 22,638 tons of ore was raised, of which 16,228 tons was shipping ore and 2,730 tons was milling ore. The shipping ore averaged 8·94 dwt. gold per ton, 1 oz. silver, and 2·25% copper. The milling ore yielded 207 tons of concentrate averaging 1 oz. gold, 0·8 oz. silver, and 0·58% copper. The sales of shipping ore and concentrate brought an income of £42,063. The working profit was £13,616. This profit is unfortunately more than wiped out by the necessity for writing down the investment account by £26,475, chiefly owing to the failure of the Van-Roi company, in which Le Roi No. 2 had a large holding. The net result of the year's work was therefore a loss of £12,859. The year commenced with a balance of £35,187, and ended with a balance of £22,327. Out of this balance, the directors have declared a dividend of 1s. per £5 share, absorbing £6,000. An option has been granted on the Van-Roi silver-lead property which is situated in the Slocan district. Additional ground known as the Giant-California adjoining the Josie and Annie is being tested under option.

Tweefontein Colliery.—This company was formed in 1907 by Henderson's Consolidated, now Henderson's Transvaal Estates, to work the colliery on Tweefontein farm in the Middelburg district of the Transvaal. The report for 1916 shows that the prosperity of the enterprise continues, and that the outlook is bright. During the year the coal sales were 436,898 tons, an increase of 50,160 tons over the previous year. The profit was £26,007, out of which £7,500 has been distributed on the preference shares, at the rate of 10%, and £15,000 on the ordinary shares, at the rate of 25%. Frank Simon is the manager.

Langlaagte Estate & Gold Mining.—The control of this company has recently been sold by Sir J. B. Robinson to the Johannesburg Consolidated under circumstances already detailed in our pages. The company was formed in 1889 to work an outcrop property in the central Rand, and for some years the mine was a leading producer. The original property showed signs of exhaustion in 1909, and the adjoining Block B property was acquired. The report for the year 1916 shows that 200 stamps and 5 tube-mills treated 595,507 tons of ore for a yield of 166,364 oz. of gold, worth £692,486, or 23s. 6d. per ton milled. The working cost was £543,558, or 18s. 3d. per ton. Out of the profit, £20,693 was allocated to capital expenditure, £35,100 was paid as taxes, etc., and £44,325 was distributed as dividend. The ore reserve is estimated at 442,423 tons in the Main Reef averaging 6 dwt., and 873,390 tons in the South Reef averaging 5·33 dwt., in each case the width being calculated at 4 ft. 6 in. These figures show an increase during the year of 201,657 tons.

Randfontein Central.—This company, operating in the far west Rand, was until recently controlled by Sir J. B. Robinson. Early this year the control was bought by the Johannesburg Consolidated, or Barnato group. The report now issued covers the year 1916, and deals with work done under the old control. During this period, an average of 730 stamps treated 2,209,622 tons of ore, for a yield of 680,982 oz. of gold, worth £2,835,735. The working cost was £2,001,337. Out of the balance of working profit £166,256 was paid as debenture interest, £91,600 was employed in redemption of debentures, £104,629 was allocated to capital expenditure, and £112,387 was paid as taxes, contribution under the Miners' Phthisis Act, etc. The net balance of profit was £402,570. The yield per ton was 25s. 8d. and the working cost 18s. 1d. The amount of development done during the year was 112,026 ft., including 2,151 ft. of shaft-sinking. The ore reserve on December 31 was estimated at 4,944,302 tons, averaging 7·8 dwt. per ton. In addition, 3,486.917 tons avering 4·6 dwt. per ton is reported as possibly payable, while 3,268,654 tons averaging 2·8 dwt. is of course rejected as unpayable. It is notable that 80% of the ore developed during the year is payable. No dividend has been paid for the year, as new the controllers desire to ascertain the actual financial requirements in regard to the mine and equipment. The results for the year 1916 compare favourably with those of a year ago. During 1915, the ore milled was 2,466,520 tons, the yield of gold 680,715 oz. worth £2,846,488, the working cost £2,202,089, other expenses including debenture interest, debenture redemption, and taxes, £675,000. The sum of £150,000 was raised for the purpose of meeting this excess of expenditure, and thereby to release £108,592 to be paid as a dividend at the rate of 2½%. In our issue of May last year we compared the position at this mine with that of the other two big properties on the Rand, the Crown Mines and the East Rand Proprietary.

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CONTENTS.

EDITORIAL

WATER troubles at the East Rand Proprietary Mines are to be combated by the application of the Francois cementation process. This method was devised in Northern France ten years ago, and it has proved successful there, and also in Belgium, Wales, the north of England, and Kent. A description of the method is given in our Mining Digest this month.

MINING Engineers heard with pleasure of the appointment of Mr. Herbert C. Hoover as Food Controller in the United States. His work on the Belgian Relief Commission provided evidence of the success of his methods and of his suitability for the new sphere of activity. His quiet and thoughtful manner, his contempt for fussy politicians, and his dislike of the hampering effect of interminable committees, are all excellent qualifications for a successful administrator. Let us hope that Government red-tape will not try to cripple his energies.

FINANCING large overseas contracts is, in official language, the object of the new British Trade Corporation or Bank that has been established by Royal Charter. Its constitution is on much the same lines as were outlined by us in December. Deposits at call or short notice are not wanted, and current accounts will only be opened with people intending to take a share in business to be helped by the bank. Working transactions on joint account with other banks will be encouraged. An information bureau will be established, to work with the Commercial Intelligence Department of the Board of Trade. The board consists of a judicious mixture of bankers, merchants, and manufacturers, and all should go well with it.

ANOTHER instalment of the late Mr. Cloutman's paper on metallurgical practice at Great Boulder Perseverance is presented in this issue. This chapter deals with the roasting furnaces, and in all probability mining engineers will find it of even more interest than the section published last month. The amount of labour involved in collecting and arranging the information and results of experience at the roasters must have been enormous. When writing of Perseverance, a month ago, we gave credit for the excellent work to Messrs. Hooper, Speak, and Williams. It is only right to say that credit is also due to Mr. R. A. Varden, who succeeded Mr. Ernest Williams as West Australian partner of the firm of Messrs. Hooper, Speak & Co. in 1910.

THE registration of the National Smelting Company Limited at Somerset House indicates the fulfilment of the contract between Mr. R. Tilden Smith and the Government in connection with the inauguration of modern zinc smelters. More than this cannot be said at present.

IN a recent editorial on fuel we mentioned the coke difficulty, due to the demand for this product being not so wide as that for the other constituents of coal. The application of coke for steam-raising purposes has been keenly studied by Mr. Thomas Clarkson, who in former years was known in mining circles as an inventor of a dry concentrator and a sampler. He has recently perfected a coke-fired steam boiler, which will be seen shortly on the "National" motor buses. The performance of this furnace will be watched with much interest.

IN writing of the establishment of home rule in South Africa seven years ago, we quoted Carlyle's description of a certain happening of bygone years, that it was a "greater event than Waterloo, Peterloo, or any other battle." The same quotation may aptly be applied to the hoisting of the Stars and Stripes on the Victoria Tower at the Houses of Parliament side by side with the Union Jack. In connection with this epoch-marking event, we may reverse the story of the prodigal son, and say that we welcome the return of the noble-hearted youngster to the arms of his foolish old parent.

SHAREHOLDERS do not always display sound judgment when exercising their undoubted prerogative of demanding the infusion of new blood on the boards or staffs of mining companies. For instance, a suggestion of this kind was made at the meeting of the Balaghat Gold Mining Company the other day. It is true that the company has paid no dividends for several years, but the agitator apparently forgot that the adjoining mines, Mysore, Champion Reef, Nundydroog, and Ooregum, have made handsome profits under the same managers. Would he also want to infuse the new blood there?

ROYAL Commissions are of various types, some being appointed to elicit information, others to shelve difficult problems, and still others to provide free jaunts to the politicians. To the last-named group may be assigned the Commission on the "Natural Resources, Trade, and Legislation of Certain Portions of his Majesty's Dominions." The Commission has issued many interim reports, and the final report has recently made its appearance. Our trust in the wisdom of the commissioners is weakened by their statement that "nearly all the tin consumed is used in the manufacture of tin-plate." As a pleasant contrast to these perfunctory reports, comes the report of the Ontario Nickel Commission, which belongs to the first group named above. As the members of this commission have direct knowledge of their subject, their report is of the greatest possible value. A short reference is made elsewhere in this issue, but next month we shall quote more liberally from this mine of interesting information.

AMONG the many important resolutions of the Imperial War Conference, the recommendation to establish in London an Imperial Mineral Resources Bureau is undoubtedly of the most direct interest to our readers. Last year we recorded that the Institution of Mining and Metallurgy, the Institution of Mining Engineers, the Iron and Steel Institute, and the Institute of Metals had presented a joint address to the Department of Research recommending the foundation of a Department of Mines and Metals for this country and for the Empire. This proposal was discussed at the Imperial Conference and was received with active sympathy. The resolution passed by the Conference states that it is desirable to establish in London an Imperial Mineral Resources Bureau, upon which should be represented Great Britain, the Dominions, India, and other parts of the Empire; that the Bureau should be charged with the duties of collection of information from the appropriate departments of the Governments concerned and other sources regarding the mineral resources and the metal requirements of the Empire, and of advising from time to time what action, if any, may appear desirable to enable such resources to be developed and made available to meet the metal requirements of the Empire; and that immediate steps should be taken by the British Government for the purpose of preparing a definite scheme for consideration by the other Governments. There are already several organizations or branches of departments that are devoted to these questions. Probably an entirely new organization, absorbing some of the best features of those already established, will meet the views of the various Governments most satisfactorily. It is better to make a fresh start without trammels than to try to revivify ancient mummies.

REVISED figures for the output of gold in Australasia during 1916 are to hand. The figures for the New Zealand output show a production of £1,199,212, which is a fall of £495,341 as compared with 1915. In our estimate of the gold production of the world during 1916, published in our February issue, we gave figures considerably lower than these. In addition returns are in from the Northern Territory. We reproduce below the official figures for the production during 1916 in Australia and New Zealand:

	£	Decrease compared with 1915 £
West Australia	4,508,532	641,695
Victoria	1,090,194	307,800
Queensland	937,288	123,415
New South Wales	459,370	103,500
Tasmania	75,552	3,232
South Australia (estd.)	24,360	1,470
Northern Territory (estd.)	6,500	—
Total Australia	7,101,796	1,181,112
New Zealand	1,199,212	495,341
Total Australasia	8,301,008	1,676,453

The continuous fall in the Australasian output is as pronounced as ever. Some idea of the decrease may be gathered by a comparison with the figures for 1906, ten years ago. In that year West Australia produced £7,379,300, Victoria £3,282,200, Queensland £2,314,700, New South Wales £1,079,400, Tasmania £255,000, South Australia £34,000, Northern Territory £54,200, total Australia £14,400,000; New Zealand £2,272,000; total Australasia £16,672,000. It will be seen that the figures for 1916 are just half those for 1906. With most of the remaining big mines at Kalgoorlie within measurable distance of the exhaustion of their orebodies, the fall will be distinctly disturbing in a few years from now. The chance for any revival or for new discoveries appears to be remote, though it is possible that Mr. E. C. Dyason's plan for systematizing the work at Bendigo may bear fruit.

Colloid Chemistry.

The time is rapidly approaching when geologists and metallurgical chemists will have to make serious study of colloid chemistry and molecular physics. It is true that a select few, such as Sulman, Free, Forbes Julian, Sydney Smith, and Goodchild, have closely followed these developments of science, and have applied them in their various researches and investigations, but it must be confessed that the average mining engineer, metallurgist, or geologist is behind the times in these matters. In fact many engineers are apt to look upon the exponents of colloid chemistry as quacks or charlatans who use the mysteries of science to impress the public with their spurious profundity. An example of this attitude is provided by the contemptuous disbelief in the claims of the Minerals Separation chemists in connection with the surface effects of minute quantities of oil, that has been freely expressed in some quarters. Our fate may be that of the prophet in the wilderness, as a result of our publishing in this issue a paper on the molecular structure of pyrite written by Mr. W. H. Goodchild, but we can assure our readers that this aspect of the conditions under which the various sulphides are formed will exercise considerable influence in the theory of ore deposits. Geologists who persevere in the study of this paper may find for themselves some applications of Mr. Goodchild's deductions. For ourselves we shall leave it to the author to work out certain ideas and suggestions.

With regard to the question of colloid chemistry, we would take this opportunity of saying that the subject is not anywhere near so difficult as may appear to many at first sight. Much of the difficulty arises from the fact that the modern development of the science is on an entirely different footing from what it was in the days of Thomas Graham, who first distinguished between colloid and crystalloid and between suspensions and true solutions. In commencing the new study it is advantageous to forget for the time being all about sols and gels, and to start direct with the "disperse" idea. That is to say, a colloid denotes a "state" rather than a "kind" of matter, and consists of the fine dissemination of one substance throughout another. The substance disseminated is the "disperse," and the other is the "medium." Both disperse and medium may be gas, liquid, or solid, though as far as we know at present they cannot be both gas in the same colloid. The meaning of the word colloid has travelled far from its Greek root, kolla, glue. A modern instance of the application of the word is to slime that will not settle, and another is to describe the condition in which unconcentratable cassiterite may exist in quartz. The science received a tremendous impetus by the invention of the ultramicroscope, an instrument which makes visible particles of matter smaller in diameter than the wave length of light. As we have said, colloid chemistry is quite simple when the fundamental idea has been grasped. Perhaps the foregoing remarks as to the method of approaching the subject may clear the way for some of our readers.

East Pool.

The recent history of the East Pool tin mine at Camborne, Cornwall, is fairly well known to our readers. It well exemplifies the combination of the luck of mining and sagacious administration. Since Messrs. Bewick, Moreing & Co. undertook the direction of affairs, many applications of modern methods have been made. In the first place, a mining geologist of high ability, Dr. Malcolm Maclaren, was commissioned to make a thorough study of the ore deposits; second, an extensive campaign of development was undertaken on the basis of his recommendations; third, the diamond drill was introduced, in spite of much local disbelief in its chances of successful application; fourth, improvements were sought in crushing and dressing practice, with wise deference to past and present Cornish experience; fifth, endeavours were made, with very fair success, to organize underground labour with the object of inducing the men to keep to their work with greater regularity. The fortune of mining is represented by the most important discovery of ore that has been recorded in our generation, in the now celebrated Rogers lode. While it is true that this lode might never have been discovered but for the geologists, we can on the other hand congratulate the geologists that the luck of mining rewarded them rather than the casual and uninstructed prospector. Luck is often mistaken for ability, and the absence of a reasonable amount of luck may indirectly act detrimentally to the reputation of the best of engineers. From this point of view, it requires a good deal of courage on the part of a mining engineer to introduce new methods of examination and exploration, particularly when his directors may doubt their value or are disinclined to provide money for what they may consider to be mere experiments. If the new methods fail, the engineer is blamed; but should they succeed, the directors often forget to acknowledge their indebtedness to him. In the case of East Pool, full and generous recognition has been awarded to Mr. C. A. Moreing and to Dr. Maclaren, as every one knows who read the recent speech of the chairman, Mr. Montague Rogers, at the meeting of shareholders.

We are fortunate in being able to present in this issue an article on the geology of East Pool by Dr. Malcolm Maclaren. For fifteen years he has been travelling from one end of the earth to another making geological examinations of old or new properties. We have heard of his work at Kalgoorlie, Porcupine, Korea, Cornwall, and elsewhere, and of the practical value of his deductions and recommendations. Unfortunately for the geological student who is desirous of learning the master's methods, the reports written by Dr. Maclaren are private documents and not usually available for publication. Under these circumstances we feel specially favoured in being allowed by Messrs. Bewick, Moreing & Co. to publish an article by Dr. Maclaren based on his report on East Pool. As an appendix to Dr. Maclaren's paper we give a description of the work done on the Rogers lode to date. Both Dr. Maclaren's paper and the notes on the Rogers lode in the appendix are illustrated by sections and plans, which clearly explain the geology and mining operations.

The application of the diamond drill in Cornwall has been justified by its performance at East Pool. Some years ago a drill of this type was tried at Dolcoath, but the cost was excessive, and as no results of value were immediately obtained, its use was discontinued. There has been a prejudice in Cornwall against this method of prospecting, and it has been said that the drill has no application in the hard Cornish rocks. Hardness in itself is of course no objection, but with wide variations in hardness, and with an acute angle between the direction of the drill and the plane of change in the rocks, the troubles of drilling are considerable. The performance of the drill at East Pool has given great satisfaction. The machine chosen was the Sullivan. In all, five holes have so far been drilled, varying in depth from 42 to 260 ft. The average rate of drilling was 1½ ft. per hour, and the total cost per foot was 12s. 9d. For the benefit of those who desire greater detail we give herewith in tabular form a general abstract of the results. The only untoward circumstance was the breakage of two diamonds, one in No. 2 hole and the other in No. 5 hole. For this reason the costs of these two holes were abnormally high. We understand that since this drill was moved to Dolcoath, the benefit of experience has proved advantageous in this connection. It was considered advisable to alter the gear, so that the rate of feed should be slower. This alteration has proved of substantial benefit, and the drill is now working more cheaply and in better adaptation to the rocks of the neighbourhood. The success of this drill has encouraged others in Cornwall to embark on similar campaigns, and before long the chances of finding additional orebodies by lateral exploration will add greatly to the interest of tin and wolfram mining in the Old County.

RESULTS OF DIAMOND DRILLING AT EAST POOL.

Number of Bore-hole	1	2	3	4	5	Average for 5 holes
Depth of Hole in Feet	260	89	79	150	42	
Number of Shifts Drilling	23	7	6	14	4	
Average Feet Drilled per Shift	11·3	12·7	13·1	10·7	10·5	11·48
Costs per Foot in Shillings:						
Labour	4·48	6·27	4·77	5·49	7·02	5·19
Carbon	5·65	*9·10	4·58	2·92	*9·52	5·61
Power	1·36	1·00	1·11	1·06	1·11	1·18
Sundry	0·62	0·98	0·64	0·68	1·07	0·72
Total	12·11	17·35	11·10	10·15	18·72	12·70

* Excessive cost due to crushing of a couple of carbons.

The Institution's Annual Meeting.

The part played by the British mining engineer in helping his country at the present time was well exemplified by the paucity of attendance at the annual meeting of the Institution of Mining and Metallurgy held on the 19th of last month. Two years ago the absentees were mostly the young men on active service. Last year the call for munitions took many of the older men. This year the national service, and munition manufacture, have absorbed still more. Moreover half of those who did attend the meeting were only able to do so by snatching a brief respite from their labours. In spite of this drawback, the meeting had several notable features. Foremost we may mention the fraternal message sent to the American Institute expressing gratification at the advent of the United States in the ranks of the Allies, fighting for freedom and civilization against military autocracy and barbarity. Among the Americans present we noted Messrs. C. W. Purington, R. Gilman Brown, and H. A. Titcomb, of all of whom it may be said that no formal alliance of the two countries was necessary to make them compatriots in the motherland. Next came the announcement, in the Council's report, that the Board of Inland Revenue had been induced to regard a mine as a wasting asset, and that some allowance for amortization of capital will be given in connection with the assessment for excess profits tax. This conversion of the fiscal authorities is so far only one of principle, and the details of its application remain to be settled. At the request of the authorities, the committee of the Institution is preparing two representative appeals. The Council's report says nothing of any extension of the principle to the income tax, but this will no doubt come later. The pleasantest of all functions at these annual meetings is the vote of thanks to the president, council, secretary, and staff of the Institution. This year it fell to Dr. Sydney W. Smith, of the Royal Mint, to propose the vote, and in happy terms he referred to the feeling of affection which we all have for the president, Mr. Edgar Taylor. The presidency is no sinecure, and it speaks volumes for his devotion to the interests of the Institution, and also for his organizing ability, that with so many interests both in mining and in national service he should find time to undertake these duties once more. The seconder of the vote, Mr. R. O. H. Spence, long a resident in British Guiana, voiced the appreciation, by the overseas members, of the many services both to the profession and to individuals rendered by the secretary, Mr. C. McDermid. The proceedings at the meeting were shorn of many of the usual items. There was no formal presidential address, and the presentation and award of medals, prizes, and post-graduate scholarships is in abeyance. Next year, we all hope, these conditions will be different, though the present position in the world strife cannot be said to be too encouraging.

The Advantages of Publicity.

The professional man has always been averse to advertising, and rightly so, for ex parte statements have no place in the advancement of science. His only opportunity of letting the world outside his own circle of friends and clients know of his abilities is to present papers to the societies and the press, or to contribute to the discussions of such papers written by his confreres. The mental attitude with regard to the publishing of individual experience depends largely on circumstances. It may happen that the experience was gained and the information collected in the course of investigations made for a client or employer, and in that case the professional man is not the sole owner of the advantages accruing from his research or examination, and, of course, he cannot give to the public the information for which his client has paid and on which his client counts for commercial profit. Then again the special knowledge possessed by a professional man may be considered to constitute his stock-in-trade, and in many cases its gratuitous presentation to the public would be almost suicidal. The employers of the professional man, on their side, naturally object that others should share the rewards of their perspicacity and application of capital. Thus without the aid and encouragement of the promptings of public duty, the dissemination of experience and information might have an attack of atrophy. For ourselves, any serious reference to the duty of the mining engineer and metallurgist in this direction is out of place, for it is obvious that we are not disinterested parties. It is more appropriate that we should point out to the professional man and to the director of mining companies some of the advantages of publicity from the merely selfish point of view.

If a mining engineer or metallurgist has some special experience that would make his services valuable, he should write an article or book to give tangible evidence of his ability. He need not tell all he knows, nor need he enter into details of application to any large number of specific cases. A judicious treatment of the question will serve to elucidate his ideas and methods, and, like Sam Weller's valentine, make the reader long for more. Thus the objection of giving away the whole of his knowledge is overcome. The reader of such articles will in most cases be more desirous of paying the writer to apply the method in his own particular case than to fog out the problem for himself. A professional man should remember also that the advantages of writing a paper do not necessarily accrue at once. Some years afterward, a similar problem may arise in another part of the world, and the inquiry goes forth for a man competent to deal with it. Some one then remembers that Blank once wrote a paper on the subject, so a search is immediately made for the fortunate Blank. It is from this point of view of publicity that the American mining engineer and metallurgist has secured an advantage. He does not believe in hiding his light under a bushel, and through the instrumentality of his literary efforts secures his first introduction to future clients. In this office we are often asked to recommend an engineer for some particular appointment, or to help an engineer to find a post for himself. In both cases our task is much simplified if the engineer has been successfully in print.

The other outstanding advantage that the writing of an article or book brings in its train is the clarification of the writer's ideas, leading to the proper collation of the information secured, or, in other words, the thorough understanding and appreciation of the various points arising. A writer must have all his facts and deductions correct before going into print. A student at college writes only for his examiners, and his errors go no farther; but when a paper is published the whole world is the critic. Thus our advice to the young professional man is that if he wants to become master of a subject the prospect of publication will act as a healthy stimulus.

The advantages of publicity are as great to the controllers of a mining company as to the professional man. We are not referring now to the issue of yearly and progress reports, or to the circulation of the considered speeches of the chairman at the shareholders' meeting, for the advantages of these are sufficiently obvious. We refer rather to technological articles giving details of the methods of mining and metallurgical treatment. A chairman may doubt the value of an article describing the reasons for adopting a particular system of development, or giving details of the concentrating plant at a gold mine where separate auriferous lead and copper products are extracted. He may say that as the company pays for this work nobody else should have the benefit. He may alternatively say that the engineer's services are devoted solely to the company, and that he will not allow the allocation of any of the engineer's time for other purposes such as writing articles. Finally the question is raised as to the possible good the proposed article can do for the board. The answer to all these objections is that the publication of technical details tends to demonstrate the soundness of the administration, and to show the solid foundations on which the business of the company is established. No doubt the word and reputation of the directors and the past records of the company are as a rule sufficient demonstration of stability, but it has to be remembered that these conditions are not universally known, and that the absence of corroborative detail may cause a confusion in the public mind between the genuine companies and imposters. Many companies of high standing encourage their engineers to write technical articles, and one controller known to us has gone as far as to say that he would not have an engineer in his service who was afraid to describe his methods publicly. A secretive mining company may be sufficiently prosperous, but the time may come when additional capital is required, or when the controllers may wish to float some other property, or extend their financial connection. On such occasions the fact that the controllers take a pride in disclosing their technical details goes a long way with the public and with the financial critics.

We are aware that the foregoing is a somewhat sordid presentation of the position, and that many readers will revolt at the suggestion of the principle of self-interest, which is after all distasteful in spite of its being prevalent in business. Nor would we have our readers imagine that this aspect is more than one of the many phases of the question. On the contrary, we have to acknowledge the generous aid of engineers and companies in helping to disseminate information by presenting papers to the societies and the press, this aid being prompted by the desire to have representative publications worthy of the country and the empire. Our remarks are intended solely for the indifferent and the unconverted.

REVIEW OF MINING

Introductory.—The entry of the United States into the war has given a more hopeful complexion to the eventual outcome of hostilities, though in the meantime the submarine menace and the decrease in the food output of the world promise hardships to the Allies. The metal position has been eased, as far as copper and zinc are concerned, but the demand for tin has forced the price up to £240. Tin is the only metal that has hitherto enjoyed no benefit from war conditions, and the Government has not so far intervened. There is every expectation, however, that steps will be taken to discourage any further advance, particularly seeing that the biggest buyer, the United States, is now among the Allies. The recommendations of the Imperial War Conference in favour of the establishment of a Department of Mines and Metals have been well received. The flooding of the Alaska Treadwell is the worst mining disaster for years.

Transvaal.—The usual deluge of reports of South African mining companies has arrived this month, and we have only space for a few short references. Of the Central Mining group, interest centres on the Crown Mines, City Deep, and Modderfontein B. At Crown Mines, the ore mined during 1916 was 2,483,285 tons, or 333,146 tons less than in 1915. The reason for the fall was partly the scarcity of labour, and partly the policy of selective mining tried for a short time during the earlier part of the year. Development in the eastern section of the property has given good results on the Main Reef Leader, where the proportion of payable ore was higher than during the previous year. On the other hand, the South Reef is showing a very low percentage of payability. The ore reserve is estimated at 11½ million tons averaging 5·9 dwt., an increase of 1½ million tons during the year.

The City Deep suffered in its early years from the mill being ahead of the mine. The development has gradually brought the output up to nearer capacity, but there is much leeway to be made up yet. During 1916, the tonnage milled was 725,700 as compared with 677,200 in 1915 and 505,300 in 1914. The yield per ton was well maintained at 39s. 7d., and the working profit at 19s. 5d. The ore reserve has been increased by 540,000 tons, most of which is in the Main Reef Leader. The average content has, however, fallen from 9·5 to 9 dwt. The Butters filter for the slime, having a capacity of 45,000 tons per month, was started in February.

The report of the Modderfontein B is excellent in every way. The tonnage milled was 543,700 as compared with 509,700 in 1915, and the yield per ton 43s. 2d. as compared with 40s. 6d. It was found during stoping that the content of the ore was higher than expected. The ore reserve has been increased by 581,210 tons and the assay-value is 0·45 dwt. higher, the figures at December 31 being 3,371,950 tons averaging 9·2 dwt. The underground position is so strong that the directors have decided to increase the capacity of the metallurgical plant from 48,000 to 60,000 tons per month. Practically the whole of the machinery required for the extension can be obtained in South Africa.

That grand old mine, the Robinson, is rapidly approaching its end. The reserve at December 31 was estimated at 490,000 tons, enough for nine months milling. It is probable that in addition 500,000 tons of Main Reef may be extracted. The surface dumps, which have supplied important amounts of feed for the mill during the last three years, are exhausted.

A. Goerz & Co. Ltd. is to reduce the nominal value of the shares from £1 to 12s. 6d., so as to release the profits from its subsidiaries, Geduld and Modder Deep, for dividend-paying purposes, and to bring the value to more nearly the market price. Last month we recorded that the new plant at the Geduld had been started and that the capacity is now 40,000 tons per month. The directors contemplate a further extension, and they also desire to have funds in hand that will enable them to bid for additional leases. They are therefore asking for powers to issue £500,000 new capital, whenever the opportunity arises.

The Daggafontein report for 1916 contains a statement by the consulting engineer relating to the development work done. The total work done to December 31 was 2,402 ft., of which 1,660 ft. was sampled, the average assay-value being 30·87 dwt. over 6·5 inches. The percentage of payability averaged 40·7% of the development footage, the average assay-value being 56·5 dwt. over 6·36 in. The payable footage comprises only short stretches, which are separated by unpayable stretches.

The results so far have not been good, but there are reasons for hoping that better results will be obtained farther to the west.

The quarterly reports of developments at Brakpan foreshadowed a gradual increase in the assay-value of the ore reserve. The report for 1916 gives the reserve at 3,054,000 tons averaging 9·2 dwt. per ton, an increase of 37,000 tons and 1·34 dwt. as compared with the figures the year before. As already recorded, the company secured the lease of the South Brakpan area, and is intending to increase the capacity of the plant to 75,000 tons per month.

The position of the East Rand Proprietary as regards ore reserves continues to become worse. The total, including 272,000 tons in shaft pillars, at December 31 was calculated at 4,200,000 tons averaging 6·1 dwt. per ton, as compared with 4,800,000 tons averaging 6·3 dwt. a year ago, and 5,400,000 tons averaging 6·6 dwt. at the end of 1914. Owing to the decrease in the number of stope faces, the monthly output diminished during the latter half of 1916. The total mined during the year was 2,051,033 tons, and the yield £2,365,107, or 24s. 4d. per ton. The working profit was £497,164, or 5s. 1d. per ton, but only £61,147 was distributed as dividend, at the rate of 2½%, owing to the necessity of keeping funds in hand. As has already been recorded in our columns, the water difficulty has been acute. It had been hoped, by driving long cross-cuts from the 26th and 27th levels and sinking an internal vertical shaft, to miss the water flow, and to reach the reefs at a vertical depth of 6,000 ft. from surface. The cross-cuts, however, struck water, and the work has been interrupted. An attempt is to be made to apply the Francois system of sealing the water flow by means of cement. A short account of this method is given elsewhere in this issue.

The Commission on State Mining has not been able to issue a unanimous report. Three of the five members, Messrs. P. Ross Frames, John Taylor, and J. L. Van Essen, are not in favour of the idea, their chief argument being that the advocates of the proposals have not proved a greater prospective benefit than is already enjoyed by the State in its share in profits. But they are evidently of opinion that there may be something in State mining, for they formulate suggestions with regard to methods in case the Government should feel inclined to venture. The other two commissioners, Messrs. R. H. Miller and Tielman Roos, each issue a minority report. The former is anxious that the State should immediately commence operations on unallocated areas on Geduld and Springs farms, and the latter is also keen on public participation in the Far East Rand. The Government has accepted the majority report, so no doubt the subsequent development of the Far East Rand will be left to private enterprise.

Rhodesia.—The output of gold in Rhodesia during March was worth £300,183, as compared with £289,734 in February and £335,368 in March last year. Other outputs were: coal 40,758 tons, copper 307 tons, chrome ore 8,391 tons.

At the Globe & Phœnix, the development during the past year or so has been restricted, and the reserve at December 31 last stood at 173,981 tons averaging 29·5 dwt., as compared with 189,200 tons averaging 29·4 dwt. the year before. Attention has recently been turned to the southern end of the property. Where the 2nd, 10th, and 12th levels have been continued in this direction, the ore disclosed has been of excellent quality, ranging from 17 to 28 dwt. per ton. The appeal by the Amalgamated Properties of Rhodesia from Mr. Justice Eve's judgment will come before the court on June 6. The directors announce with regret the sudden death from pneumonia of Mr. H. A. Piper, who had been with the company for the whole of the 22 years, first as manager, and latterly as consulting engineer.

The Golden Kopje has been one of the bad speculations of the Gold Fields Rhodesian Development Company. Milling commenced in 1914, but losses have been made continuously. These adverse results are due partly to the difficulty of preventing the soft country rock coming away with the ore, but chiefly to the irregularity of the deposits. There is no option but to suspend operations, and a meeting of shareholders has been called for the purpose of arranging the liquidation. The company's liabilities are greater than the assets, so shareholders stand no chance of receiving anything.

The Lonely Reef has an excellent reputation as an example of persistence of ore in depth. As recorded in our February issue, the 17th, or lowest, level is in rich ore. It is now stated that for 321 ft. the assay-value is 95½ dwt. over 24 in., and that the ore reserves, at 145,000 tons, averaging 20 dwt. per ton, show not only an increase in tonnage but an increase in assay-value of 5 dwt. as compared with the figures a year ago. An 18th level is being opened.

West Africa. — The output of gold in West Africa during March is reported at £158,727, as compared with £104,892 in February, £131,665 in January, and £150,987 in March 1916. In our last issue we drew attention to the obvious discrepancy in the February returns. It is now evident that some item omitted from the February figures has been included in the March returns.

Australasia. — As recorded in our March issue, exploration below the 11th level at the Waihi gold mine has been suspended, owing to labour being unavailable. The developments at depth continue to be unfavourable, and the Dreadnought lode is the only one of the many lodes to give good results on the 11th level. Work is now devoted solely to the mining of the reserves. The yield during 1916 was worth £350,059, obtained from 194,231 tons of ore, and £99,181 was paid as dividends, being at the rate of 20% free of income tax. These results are much the same as those to which shareholders have been accustomed during the previous four years, but the present tonnage and output are less than half of what they were in the palmy days. The ore reserve on December 31 last showed a decrease of 92,639 tons on the year, but still stood at 1,400,000 tons. Ten years ago the editor of this Magazine referred elsewhere to the Waihi as the greatest gold mine of the world. As all mines do, sooner or later, the Waihi has passed its zenith, but the high reputation of its engineers and directors remains unchanged. The financial position has always been strongly maintained, and the reserve fund, amounting to £380,965, is invested in the soundest class of stocks.

India.—Development at the Hutti Nizam's gold mine in Hyderabad has not given good results lately. Levels were opened at 2,660 ft., 2,800 ft., and 2,950 ft., but no large body of high-grade ore was opened. The shaft has been sunk to 3,200 ft. and a level is being opened. The future of the company depends on the results obtained there. During 1916, 26,360 tons of ore and 30,520 tons of sand and slime were treated for a yield of gold worth £71,690, and £7,000 was distributed as dividend, being at the rate of 10%. Mr. Llewellyn Parker, the manager, reports the reserve on December 31 last at 31,450 tons.

Malay. — The fortune of the Lahat tin mine has been better recently, though no great period of profitable working is in sight. The property was introduced by the same parties as the Tronoh. From 1909 to 1913 satisfactory dividends were paid, but for the next year or two the workings were in poor ground, and not only were the profits extinguished, but financial loss was suffered. During the year 1916, better ground was chosen, and 438 tons of tin concentrate was extracted, as compared with only 264 tons the year before. The revenue was £47,558, and £6,000 was paid as dividend, being at the rate of 5%, while £5,000 was placed to reserve. The same rate of profit may be expected during the current year, but subsequent results are doubtful.

The Federated Malay States reports a yield of gold worth £67,373, during 1916, as compared with £72,234 during 1915. Nearly the whole of this came from the Raub mines in the western part of the State of Pahang. These mines are worked by an Australian company having its headquarters in Brisbane.

The output of wolfram concentrate in the Federated Malay States during 1916 was 311 tons as compared with 234 tons in 1915, and the output of scheelite 204 tons as compared with 57 tons.

Cornwall.—Mr. John M. Iles has recently made an examination of the Geevor tin mine, and his report has been issued. He agrees that the main shaft should be sunk another 170 ft., and that additional crushing and concentration plant should be provided so as to bring the daily tonnage from 100 to 150. The cost is estimated at £10,000.

Canada.—Legislation affecting the nickel-mining industry was passed by the Ontario Legislature during its recent session. The report by the Nickel Commission recommended an increase in the rate of taxation on the profits of mining, now liable to a provincial tax of 3%. The International Nickel Co., under a special arrangement with the Government, has hitherto escaped its fair share of taxation by the payment of a flat rate of $40,000 per annum, though of late years its output has very greatly increased. The nominal value placed on the matte exported has been a mere fraction of the real value, and the enormous profits from the refined metal have contributed little to the provincial treasury. The Mining Tax measure proposes to rectify this anomaly by a graduated tax on the profits of nickel and nickel-copper mining companies, and the adoption of stricter methods of ascertaining the actual value of the nickel matte shipped to the United States. The rate of taxation is fixed at 5% on profits from $10,000 to $5,000,000, with an increase of 1% on each additional $5,000,000 of profit, the tax being made retroactive as from January 1, 1915. In fixing the amount of profits, the market value of the refined product is to be ascertained, from which is to be deducted the cost of marketing and the various processes of refining and treatment, with allowances for depreciation, and the balance to be taken as the profit. Sales of the product of a nickel mine by a subsidiary company to another incorporated company which controls the selling price are not to be deemed bona fide. On mines other than nickel and nickel-copper mines the tax is 3% on all profits from $10,000 to $1,000,000, with an increase of 1% in rate on each additional profit of $5,000,000. It is estimated that under the new system the Province will receive about $1,000,000 per year in taxes from the International Nickel Co. in place of $40,000.

There is a chance of the tangle of the Granville Mining Co. becoming unravelled, now that the Consolidated Gold Fields has secured the appointment of a receiver under an order of court. The company holds shares in the North West Corporation and the Canadian Klondyke Co., whose finances are also in confusion.

United States.—The long expected disaster at the Alaska Treadwell group of mines has happened, the sea breaking into the workings on April 21. The ore deposit dips under the Gastineau Channel. The lode is wide, and the method of mining has been necessarily cheap, so that subsidence and fracturing of the hanging wall naturally introduced the element of danger. In the issue of the *Mining and Scientific Press* for February 10, Mr. T. A. Rickard foretold an immediate catastrophe, for salt water was at that time percolating into the workings. Unfortunately copies of this issue of the paper intended for England were lost in transit, so that the warning was not generally circulated here. The water has filled the workings up to the sea level, which means that the whole of the ore deposit is lost in the Treadwell, 700 ft., and Mexican mines. The Ready Bullion, which is farther along the lode, is not within the area of crushing, so it may be considered safe. It is well known, of course, that the deep levels have given poor results in development, and it was an open question whether a continuation of work was advisable; but in the upper levels there remained many years' supply of profitable ore. The engineers may possibly find some means of reclaiming part of these reserves, but the chances are not hopeful. Another point of interest in connection with the mines is that, quite recently and without any official notification, amalgamation was abandoned and the whole of the gold recovered in the pyritic concentrate. These metallurgical variations are not of the same interest now.

The position at the Plymouth Consolidated gold mine, in Amador County, California, has been further strengthened by the excellent developments on the new ore-shoot, discovered a year or more ago when cross-cutting to the main orebody on the 1,200 and 1,400 ft. levels. The shoot has been proved on the 950 and 1,065 ft. levels, and large amounts of ore disclosed. During 1916 the mill treated 125,000 tons of ore for a yield of £140,154, out of which £36,000 has been distributed as dividend. It is not often that the re-opening of an old mine gives such excellent results, and the incident should help to break down the old prejudice. In this case Mr. W. J. Loring had sound information as to the reasons for the previous closing of the property, and his judgment has not been at fault.

Tin-smelting was established over a year ago near New York by the American Smelting & Refining Co., under the technical direction of Mr. E. V. Pearce, of Williams, Harvey & Co. The full terms of this deal are now divulged by the National Lead Co., whose report announces the purchase of half the shares of Williams, Harvey & Co., and the formation of an American company, the Williams Harvey Corporation.

Spain.—The Tharsis Sulphur & Copper Co. has presented its fiftieth annual report. During all these years dividends have been regularly paid, the total distribution being 925%, or an average of 18½% per year. The bulk of the expenditure on property and plant has been written off, and the nominal capital of the company, £1,250,000, is now represented in the balance sheet by over £800,000 in cash and securities. The mines stand in the balance sheet at only £43,413, as against their original valuation of £732,642. The company has always been closely identified with Tennants, the Glasgow chemical firm. It is interesting to note that the Steel Company of Scotland was founded for the purpose of utilizing the iron oxide left after the roasting of the pyrite at the chemical works, in conjunction of course with other raw materials. Of recent years the Tharsis company has found it advantageous to decrease the amount of leaching of low-grade cupriferous pyrite at the mines, and instead to deliver this material direct to the alkali makers. At the same time more of the pyrite of higher copper content is being smelted in Great Britain.

ORE TREATMENT AT THE PERSEVERANCE MINE,

KALGOORLIE, WEST AUSTRALIA.

By the late W. R. CLOUTMAN, A.R.S.M.

(Continued from the April issue, page 208).

In this section of the article, the author describes the roasting practice. The design of the furnaces embodies the combination of the Edwards Duplex system and the Holthoff-Wethey cooling hearth.

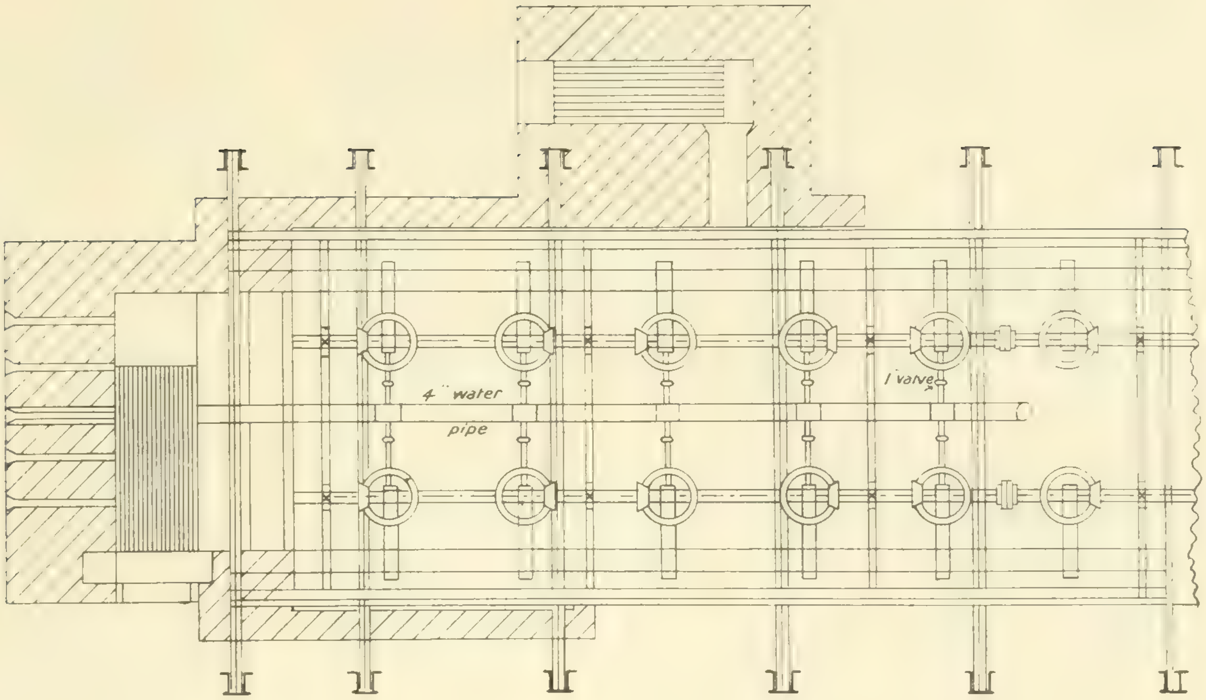
ROASTING FURNACES.—There are 6 roasting furnaces, being a combination of the Edwards "Duplex" system with the Holthoff-Wethey cooling hearth. Four are together in the big roaster house, and two in another house at right angles to the first, with the main flue in between. The roasters are built on girder frames and H beams, so as to be about 3 ft. above the cooling hearth at the feed end and 1½ ft. at the discharge end. The system of beams into which the brickwork is built permits of the beams exposed to heat expanding and contracting, tension rods keeping the main members in place. The furnaces are 121 ft. long, and 13 ft. 6in. high at the feed end, with the crown 20 in. above the roasting hearth. This hearth is carried on corrugated iron sheets, laid on H beams running the long way of the furnace; these in turn being supported by the cross beams 6 ft. apart. The bed of this hearth is of fine residues and is about 1½ ft. thick. Rotating rabbles expose the ore to the action of heat, and cause it to travel down the furnace, at the end of which it falls through ports on to the cooling hearth below the furnace. Chain rabbles take the roasted ore along this cooling hearth and finally discharge it on to a screen, through which it falls on to a push conveyor. The slope of the hearth is 18 in. in its length, 121 ft.

FURNACE FEED.—The ore from the feed conveyor falls into two hoppers at each furnace. These hoppers are about 5 ft. square at top, by 6 ft. in depth. They narrow down to a throat through which the ore falls on to a feed plate. This plate is a fixture and lies horizontally beneath the hopper. A square bar about 1 in. thick is attached to two arms, connected to an eccentric, which causes the bar to slide to and fro on the plate, to a maximum extent of 1 in. As long as the hopper is kept full, the feed plate is always covered with a layer of ore 3 in. thick, and the movement of the bar causes ore to drop off the plate, on alternate sides, into the furnace. The speed of the shaft carrying the eccentrics is 7·2 to 8·7 r.p.m. The eccentric is adjustable and the feed is altered by varying its throw. On roasters Nos. 1 to 4, an increase or decrease in throw of $\frac{1}{16}$ in. makes a difference of 8·35 tons per 24 hours; on roasters Nos. 5 and 6, of 9·4 tons per 24 hours. Unless the hopper is kept full, the ore will fall down past the feed plate in a heavy stream. Therefore, if the ore in the hopper gets low, the open spaces at the sides are blocked up until the hopper is again full.

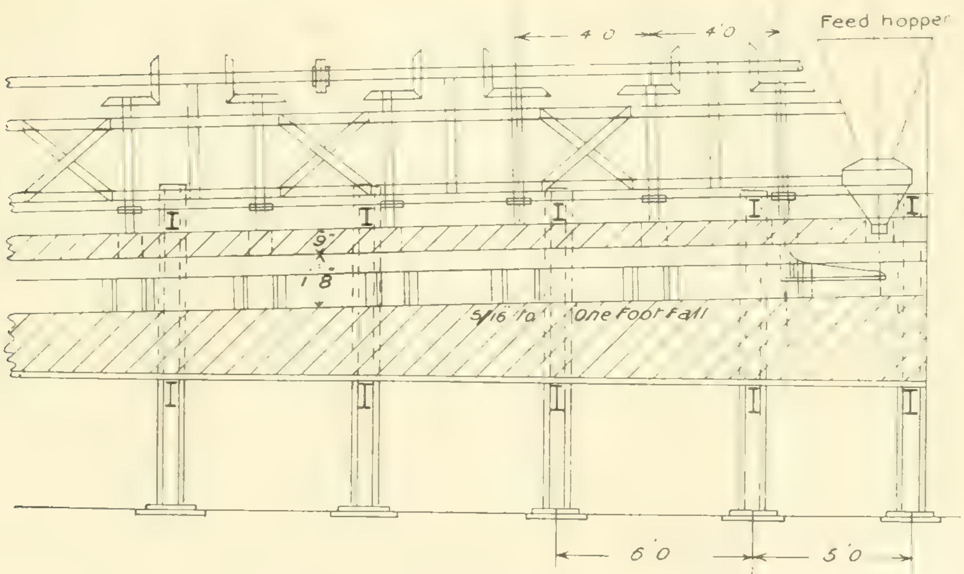
TOP RABBLES.—The turning over of the ore and its movement down the hearth is accomplished by 28 pairs of rabbles, driven by pinions and crown wheels, from the shafts running the length of the furnace. The shafts are driven by two spur wheels (5 ft. diameter) engaging with each other, and keyed to the shafts. The spur wheels are rotated by a pinion, and the latter through bevel wheels, pulleys, and belting from the main shaft line which runs along the furnace house at the feed end of the roasters.

Three types of rabbles are used: (1) Dry rabbles, which deal with the ore at the feed end of the furnace, and are not exposed to great heat; (2) Wet rabbles, exposed to greater heat and consequently require to be water-cooled; (3) "Special" rabbles, used just opposite the fire-boxes, and made to withstand the greatest heat in the furnace.

DRY RABBLES.—These are the six pairs of rabbles next the feed hopper. The first two pairs revolve the same way, so as to keep the bottom of the hopper clear; the rest revolve alternately in opposite directions, so that the ore shall remain longer in the furnace and be more exposed to heat. The upright part of the rabble (the shank) is round and hollow. It has a flange at the top, by which it is bolted to the short shaft which carries the crown-wheel. The toe of the rabble is flat and blades (tines) are fitted on to it, which do the actual stirring of the ore. There are five of these blades on each rabble, of which three are set so as to move the ore forward, and the other two allow the ore to fall over them, without it being carried forward. A lug near the heel of the rabble holds the blade at that end in place, and a pin at the end of the toe pre-



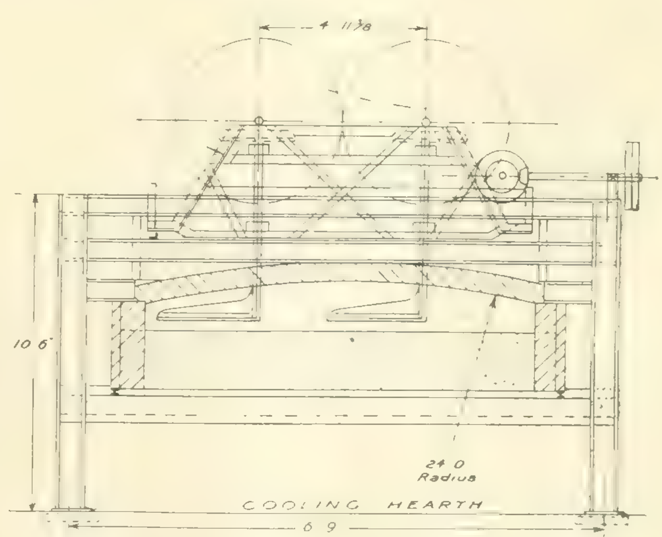
Plan of Fire-Box (Discharge) End of Roasting Furnace.



Sectional Elevation of Feed End of Roasting Furnace.

vents the blades slipping off. These rabbles are made of cast iron, and under the influence of the heat and sulphur in the furnace they become corroded, and break off very easily if they meet with any unusual obstruction. A cast-iron box, built into the furnace crown, and normally fitted with bricks, allows the rabble to be removed when necessary.

Wet Rabbles. — The shank of these rabbles is cast hollow, and a copper tube passes down it, through which water can be admitted to the rabble. The toe is also tubular, with flanges at the sides, on to which the tines are slipped. Plugs are screwed into the end of the toe; when removed, the toe



Cross Section of Roasting Furnace.

can be cleaned out. The circulating water passes from a 4 in. main running the length of the furnace, through side branches and valves, on to trays, which deliver the water through the hollow stems and copper tubes. The water runs into the toe of the rabble, and passes up the annular space between the copper tube and the shank wall through an outlet at the top of the shank. The water from the outlet runs into an annular trough surrounding the rabble shank, and thence through pipes to the cooling tanks.

The water-cooling of rabbles exposed to heat is of great importance. If the supply valve is closed off, or the copper tube or outlet choked up, the toe of the rabble soon gets red hot, bends, and breaks. A tour is made round the tops of the roasters, at least twice every shift, to see that the water-cooling apparatus is in good order. Enough water is turned on to prevent steaming of the water at the shank outlet and the circulation of the water through the rabbles is attended to. If the outlet pipes or copper tubes block up, they are cleared with a piece of bent wire, or by turning water full on, or, if this fails, by applying compressed air. The troughs must not be allowed to run over, as the crown of the furnace is unnecessarily cooled thereby. The temperature of the cooling water is raised by about 25 to 30° F. A perforated web on the inside of the heel of the rabble serves to strengthen it and is used when removing rabbles.

SPECIAL RABBLES.—These rabbles differ from the ordinary wet ones in having longer shanks, a copper tube in the toe serving to make the water travel to the end of the rabble toe, and two water outlets instead of one. The copper tubes in the shank and toe are joined by a T-piece. Before the time of the fire in 1909, the side fire-boxes on each roaster were opposite, and the intense heat produced in the furnace at that point caused much trouble with the special rabbles there. With the boxes in their present positions, the lives of these rabbles have been greatly prolonged. Instead of using cast iron boxes where the shank passes through the furnace crown, oval shaped plates are employed, simply laid on the crown; the boxes in use before became bent as a result of the great heat, and caused trouble when removing the rabbles. Only the two pairs in the centre of the furnace opposite the fire-boxes are special rabbles.

The last pairs of rabbles revolve twice as fast as the others, so that the discharge end shall be kept clear. The speed of the slow rabbles is $3\frac{1}{2}$ r.p.m., and of the fast rabbles 7 r.p.m.; the speeds in furnaces 5 and 6 are 4 r.p.m. and 8 r.p.m. respectively.

The water-outlet points in the same direction as the toe of the rabble. This is used when setting a new rabble. It is made to point in the same direction as those diagonally opposite, and as those next but one on either side of it.

COOLING-HEARTH RABBLING GEAR.—The rabbles used on the cooling hearth are of the Holthoff-Wethey type. The stirring blades are fixed on straight bars, which are carried by small carriages on wheels, and drawn by two endless chains, one on either side. The return journey of the rabbles was formerly through the furnace, but since the Edwards "Duplex" system was adopted, the return track has been along rails 18 in. above the cooling hearth. The chains are driven by sprocket wheels and supported at intervals by rollers. A tension carriage at the discharge end of the furnace keeps the chains taut. There are 8 rabble bars of 4 in. piping, bolted to the carriages at both ends. They carry 22 blades on their lower side. Under the earlier system, the rabbling on the two hearths was effected by having blades on both upper and lower sides. The blades are set on the bars, so that they alternately furrow the ore towards and away from the centre line of the hearth. On the bars furrowing away from this line, the last pair of blades at either end of the bar are set in the opposite way, so that the ore is not taken on to the path of the chains. The blades are set 5 in. apart, and are about $8\frac{1}{2}$ in. wide, and $6\frac{1}{2}$ in. deep. The chains are held to the rabble carriages by two $\frac{1}{2}$ in. bolts, passing through a special link, which fits into a recess in the carriage.

The under-gear is now driven directly from the main shafting, and not, as formerly, from the feed shaft. The rabbles travel one complete round (227 ft.) in $5\frac{1}{4}$ minutes.

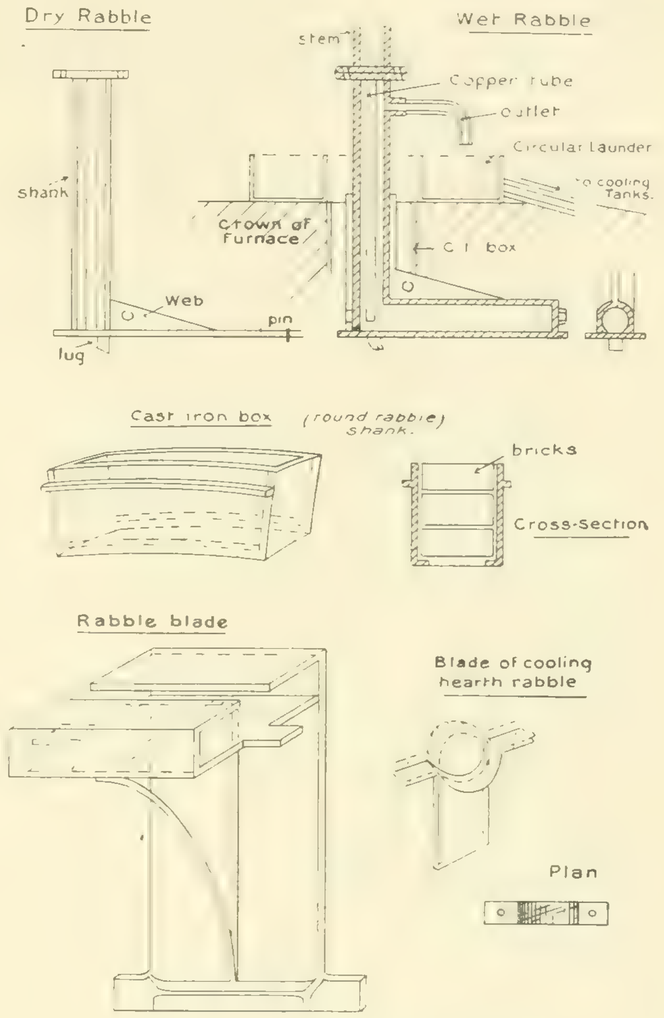
The hot ore discharged from the back end of the furnace takes 3 hours to travel down the cooling hearth, so that the reduction in temperature is considerable. This is economical in consumption in cyanide treatment. If the roast were foul, the sulphur in the partly desulphurized ore would continue to be oxidized during its passage down the hearth, if push conveyors had been installed in place of rabbles.

When cold, the roasted ore should be of a light buff colour, which when mixed with cyanide solution in the pans and vats, turns to a dark chocolate colour, with a decided reddish tinge. A dark or greyish tint in the cold dry ore is usually indicative of high sulphur, though the colour of the roasted ore is not always a reliable test of its sulphur contents.

FIRE-BOXES.—The main fire-boxes are set about half way along the furnace, one on either side. The leading one is 50 ft. from the feed end of the furnace, and the second box is 10 ft. behind the leading one. The boxes have sides and crowns of fire-brick. The crown is built dome-shaped. The opening into the furnace is in the side of the fire-box, which is built up against the furnace; there is a bridge between box and furnace which extends to about 1 ft. above the ore in the hearth.

The firing grate is 6 ft. by $2\frac{1}{2}$ ft., and has 9 fire-bars 5 ft. 6 in. by $2\frac{1}{2}$ in. by $1\frac{1}{2}$ in. The back of the fire-box is strengthened by an iron plate, secured behind the upright stays. The grate is about 4 ft. 6in. above the level of the cooling hearth, but the ground in front of it is raised about 1 ft. above this hearth. The door of a fire-box is of fire bricks in an iron frame, which can be pulled up or down in slides. A wire rope attached to the top of the door and passing over pulleys carries a counterweight to facilitate opening of the door. Just below the bottom of the door and fixed to the outside of the box is a horizontal roller, a great aid when firing a box with big logs. There is also a fire-box at the discharge end of the furnace.

FUEL AND FIRING.—The sole fuel used is wood, and consists of logs 5 ft. long, obtained from the bush up to 100 miles from Kalgoorlie, and supplied by firewood companies. A large reserve of wood fuel is stored on the lease to tide over temporary cessations of supply. The chief varieties of wood used are white gum, red (York) gum, tea-tree, gimlet, and mulga. All these woods, except gimlet, are frequently eaten away by ants, only an outer shell being left. These hollow logs often hold a lot of sand, which forms clinkers in the fire-boxes. Mulga tends to burn with a very hot flame, so that, with it as fuel, frequent firing is necessary. Gimlet forms a feathery ash, which tends to choke the fire-bars. The best type of log for firing purposes is about 6 in. in diameter solid, and neither very dry nor green. Large logs, though useful for making the bottom of a fire, since they keep the bars free and allow the draught free access, are not desirable, being awkward to handle when firing; and as they only burn slowly, it is necessary with them to fire on quarter and half fires. Very dry wood burns too fast. If the logs are green it is again necessary to fire on quarter and half fires. If the wood is small throughout, fires must be built chock fashion, and frequently fired, since otherwise the grate gets choked up. Long-flaming fuel is desirable.



DETAILS OF RABBLE CONSTRUCTION.

One of the essentials of roasting is that the fires be kept clean. If the grates are allowed to choke, air is not admitted to the furnace, and instead of being roasted, the ore is smelted, with production of clinker and consequent trouble with rabbles. The logs should be put in so that their ends are 1 ft. inside the door; they then lie wholly on the grate.

The two side fire-boxes are fired alternately, a fire taking about $1\frac{1}{2}$ hours to burn down, so that the furnace never cools down very much. Formerly the side boxes were opposite each other, but the excessive heat produced in the furnace resulted in the ore clinkering, rabbles breaking, etc. The back or end fire-box is only fired very lightly. Once the combustion of the sulphur has been started the sulphur will provide almost enough heat itself to continue the process. The heat derived from the combustion of the sulphur is of very material assistance in keeping the furnace hot. If the feed is not regular, the furnace tends to get cold, through the absence of this source of heat at the times when the feed is small or off. The back fire-box is fired heavily to get the furnace hot again after a stoppage. The consumption of firewood in the roasters is 260 lb. per ton of ore milled. In September 1913 the cost of firewood was equivalent to 1s. 7d. per ton of ore.

DRAUGHT AND TEMPERATURE.—A steel plate goose-neck $4\frac{1}{2}$ ft. diameter enters each furnace at the feed end and discharges the gases into a brick flue 290 ft. long. In this flue settles a large part of the very fine ore carried over by the draught. Each day-shift a man is employed raking out flue dust and returning it, by an elevator, to No. 1 furnace. At the end of the brick flue is a steel chimney stack, $8\frac{1}{2}$ ft. diameter and 100 ft. high. Furnaces 1 to 4 get their draught through this stack; furnaces 5 and 6 have independent stacks, each 60 ft. high. No. 1 furnace is the nearest to the stack, and so gets the best draught, while No. 4 gets the least. Normally the dampers on Nos. 1 and 2 are three-quarter open, and on No. 3 and 4 full open. The draught gauge is of the "Phœnix" make. On its dial, 25 points equals $\frac{1}{4}$ in. of water. The draught should be 30 to 35 points; Nos. 3 and 4 get less than this. Nos. 5 and 6 have a draught of 50 to 60 points, and cannot be given less draught, or they will not draw satisfactorily. The high draught of course means a higher consumption of fuel. If the draught falls to below 25 points, the roast will, as a rule, be bad. With a north or an east wind, and with a heavy atmosphere, the draught may come down to 23 points, with dampers full open, and unless the feed is decreased, bad roasts must ensue. Temperatures in different parts of various furnaces have been ascertained with the aid of a Callendar electric pyrometer. The temperature at the goose-necks, where they enter the main brick flue, is 370° F., the temperature of the ore at discharge is 465° F., and the temperature of the ore, after it has travelled the length of the cooling hearth, where it reaches the cross push conveyor, is 140° F.

NOTES ON ROASTING.—For good roasting it is necessary that: (1) the ore should be as fine as possible, consistently with avoidance of dusting; (2) the feed should be regular; (3) the fires should be kept clean and the temperature regular. Air can be admitted through inspection doors every 6 ft. down both sides of the furnaces. In normal running, the only doors left open are the last pair at the discharge end. The fires should not be so hot that the ore sinters. If the fires are very hot, or the grates are not cleaned, or the top gear temporarily stopped, a foul roast is avoided by admitting air through the doors of the side fire-boxes. If the roast in a furnace suddenly falls off, normal conditions can often be restored by lifting up these doors and letting in an excess of air; this, of course, cannot be kept up long, as the fires burn away too fast. When roasting concentrates, or ore high in sulphur, it is advisable to open the inspection doors next the fire-boxes.

The furnaces should be at a cherry red heat 20 to 25 ft. from the feed end. The red hot ore, after passing the second fire-box, should be very slightly sintered, so that it falls away easily from the rabble blades, and so gets thoroughly turned over and oxidized. If sintering is at all marked, sulphur will be retained in the roasted ore. At this point sulphur can be seen burning off. The glowing ore should not show dark streaks; these are partly roasted ore. The roast is really finished after the second fire-box, but the ore is kept in the furnaces until all the sulphur is burnt off. If allowed to cool too quickly, sulphur will be retained. After the second box, the furnace (except for the glowing ore) should be dark; the ore also should be dark 15 to 20 ft. from the discharge end, though sulphur can still be detected burning off, where the ore discharges, at night. If the roasts in a furnace are consistently bad, though the fires are properly attended to, with good fuel, and water circulation through the rabbles is all right, the only remedy is to decrease the feed, and put it on to some other furnace which is roasting well. There are four firemen on each shift, each attending to three side fire-boxes, and one or two end ones. There is also a furnace-runner, who looks after the water circulation of the rabbles, and any repairs to top or bottom gears, and an ashpit man. On day-shift, there is an oiler, who sees to the lubrication of rabble pinions and crown wheels, etc., and two repair-gang men. The furnaces work at their fullest capacity, that is, 100 to 120 tons per day.

It has to be remembered that the sulphur in the ore is only 3%; if material higher in sulphur was treated, the feed would have to be decreased and more air admitted.

(To be continued).

THE GEOLOGY OF THE EAST POOL MINE

AT CAMBORNE, CORNWALL.

By MALCOLM MACLAREN, D.Sc., M.Inst.M.M.

THE most important event in the recent history of mining in Cornwall has been the rejuvenation of East Pool, not merely because of the intrinsic value of the recently discovered Rogers lode, but because of the hope it affords of the successful resuscitation of other apparently gutted or completely abandoned mines in the Duchy. The East Pool company holds the setts of East Pool and Wheal Agar. Both are old mines. Their period of greatest activity dates from 1835, but Wheal Agar was an "old mine" even at that date and had long been worked for copper.

The value of the minerals produced by these two setts during the last eighty years of continuous working is shown below.

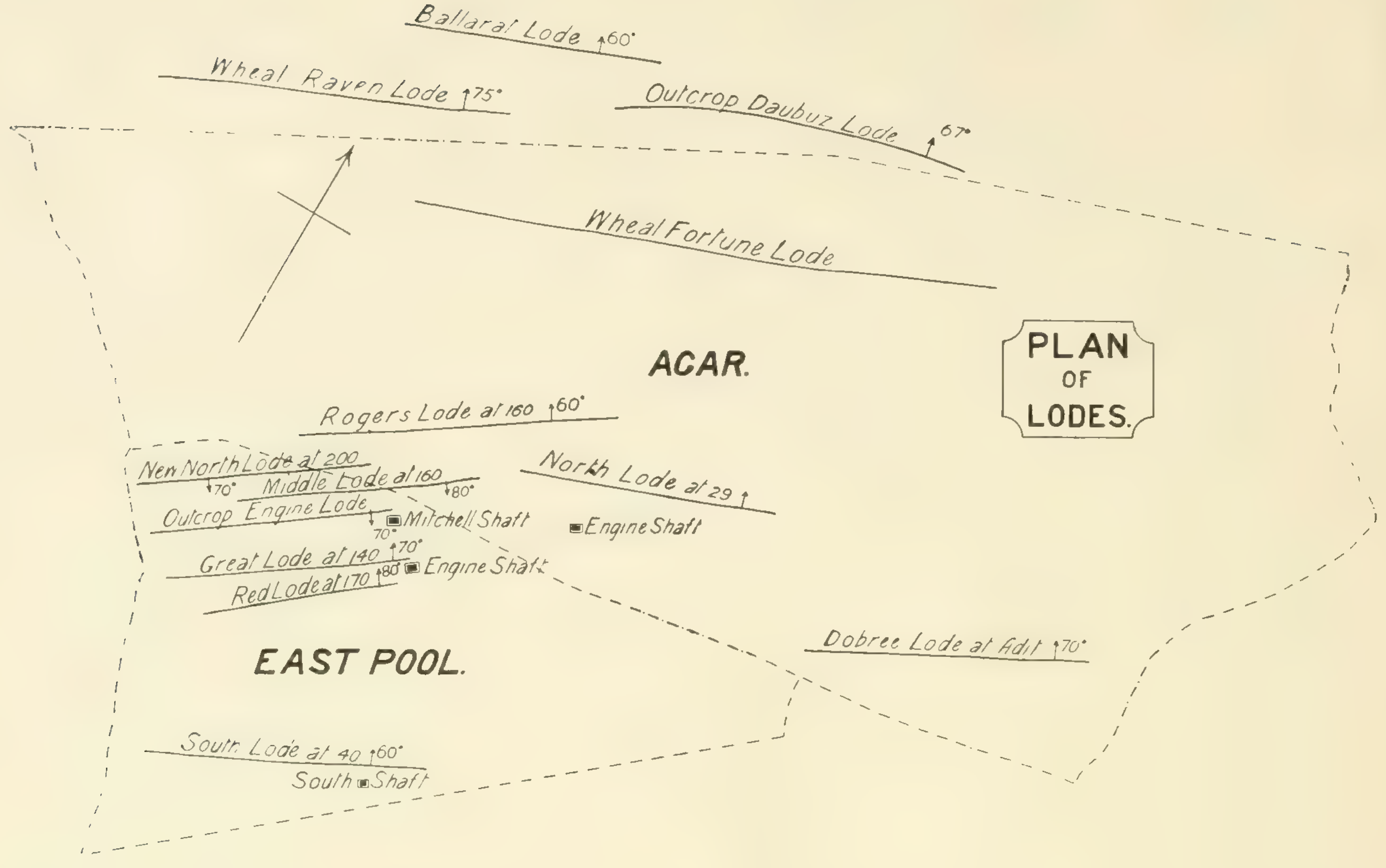
GENERAL GEOLOGY. — The East Pool mine lies midway between the towns of Redruth and Camborne, its western neighbour being South Crofty, and its southern neighbours Tincroft and Carn Brea, both of which lie on the eastern extension of the famous Dolcoath series of lodes. The ground to the north and east of East Pool is at present unworked. The principal surface rock of East Pool is "killas" (slate), through which "greenstone" sills and elvan dykes have been intruded. Granite occurs at a depth of 140 fathoms in the main workings, but does not outcrop at the surface nearer than 1,000 ft. south of the southern boundary of East Pool sett.

A brief résumé of the geological history of the area will suffice to indicate the relations of these rocks. The killas is the oldest rock (Ordovician). Through it was intruded the greenstone (probably Carboniferous) which apparently occurs as sills intercalated between the bedding-planes of the killas. In post-Carboniferous times these rocks (killas and greenstone) were faulted and folded by the strong earth-movements that preceded and accompanied the intrusion of the Cornish granite. After the partial consolidation of the granite, renewed pressure expressed from the main granite magma further fluid granitic matter which filled the fissures (mainly E-W) then open in the killas on the flanks of the granite domes, thus giving the "elvans" (mostly granite-porphyry) which are identical in chemical composition with the granite but are much finer in grain. Following the elvans along the same or similarly disposed fissures came the metalliferous gases and solutions that altered the walls or filled the open spaces of the then accessible fissures with minerals of economic value (tin, tungsten, copper, &c.). The pre-granitic fissuring of the killas, the intrusion of the granite with attendant fissuring, the subsequent fissuring of the granite and killas with intrusion of the elvans, and the lode-filling, may all be regarded as successive phases of a single long-continued period of earth pressure; or, in a narrower sense, the granite, elvans, and the metalliferous lode-filling may be considered as successive phases of the magmatic segregation of the granite, just as the gold lodes are normally the end expression of the segregation of quartz-diabase —granodiorite magmas, in the latter case the elvans being represented by albite-porphyries. It is impossible to fix the age of lode-filling in Cornwall more closely than to say that it was post-Carboniferous and pre-Triassic, and that it was probably much nearer the former than the latter.

The killas of East Pool, as nearly as may be made out, dips at high angles northwards (away from the granite dome), but owing to the great alteration caused by the heat of the granite and by the gases and solutions arising from it, the dip is obscured in the mine workings and can only be assumed from that of the less altered areas further north. It seems clear that the killas was highly fissured, broken into blocks, and even brecciated in places before the intrusion of the granite. The effect of the granite on the original slate near the contact is marked by the conversion of the latter to a con-

VALUE OF OUTPUTS AT EAST POOL AND AGAR FOR THE PAST 80 YEARS.

	Tin Ore £	Copper Ore £	Arsenic £	Wolfram £	Total £
East Pool, 1835-96	1,333,000	430,692	83,433	25,897	1,873,022
Wheal Agar, 1847-96	286,378	26,630	20,936	45	333,989
East Pool & Wheal Agar, 1897-16	1,022,829	2,658	111,995	106,662	1,244,144
Totals	2,642,207	459,980	216,364	132,604	3,451,155



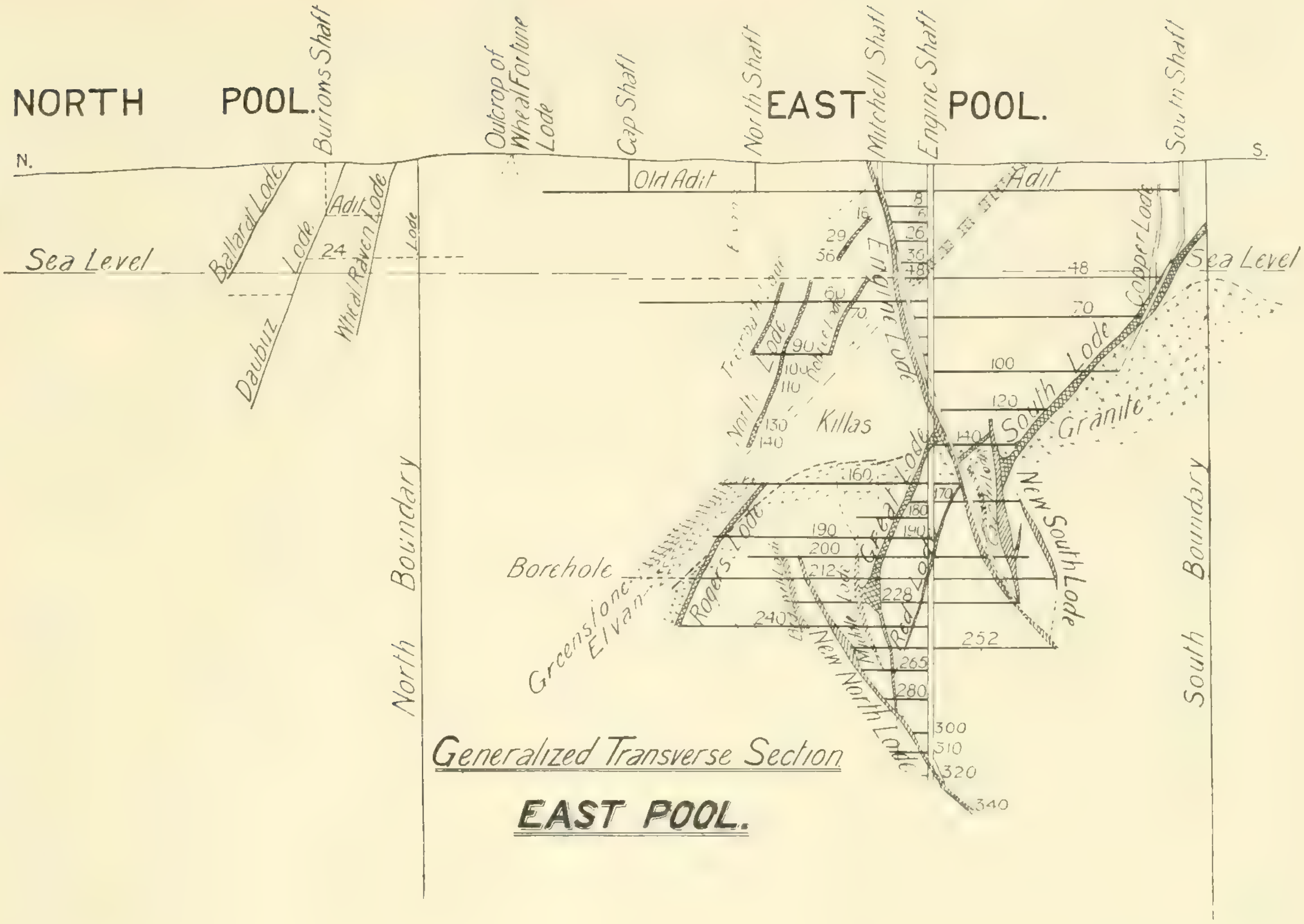
torted mica-schist. For about 500 ft. out from the contact abundant andalusite (with muscovite and biotite mica) has been developed in the slate. This feature (which is apparent as a rule only under the microscope) will probably be found of considerable value in future prospecting as marking approach to the granite. Beyond the andalusite-slate zone the metamorphism of the slates is indicated by the development of knots and spots of mica (mostly biotite) and carbonaceous matter. These "spotted slates" extend as far as two miles north of East Pool. Elsewhere round the granite dome, where the underground contour of the granite is very steep, the "spotted slate" zone extends only from 400 to 800 yards from the contact. It therefore seems a fair assumption to consider that north of East Pool the granite boss of Carn Brea extends northward beneath the killas at depths not greater and probably much less than the foregoing. Since the Camborne-Redruth area copper lodes in the killas normally give place downwards to tin lodes in the granite, the question of the depth of the granite northward of the known tin lodes is naturally one of prime importance.

Only one sill of greenstone occurs in the East Pool ground. This outcrops between the South and New Engine lodes and passes from W.S.W. to E.N.E. across the sett. It is probably not continuous throughout, and probably also varies considerably in thickness. This greenstone sill must have been well known in the early days of East Pool, but as it dipped northward, being cut by the New Engine lode at about the 48 fathom level, it passed away from the modern workings. During the past year, however, what is probably its extension in depth has been cut in the hanging wall of the Rogers lode at the 160 and 212 fathom levels, thus perhaps accounting for the failure of the Dobree and North lodes to carry copper in depth, since the general rule (to which Wheal Seton apparently gave a marked exception) is that lodes when cutting through greenstone are invariably poor.

Petrologically the "greenstone" is a fine-grained basic rock, probably an original diabase, now carrying much garnet and epidote (these often in thin veinlets) with much colourless or green secondary pyroxene.

Granite was encountered in the main workings of East Pool at about the 140 fathom level. Its occurrence is best shown by the accompanying section. It is a somewhat coarse tourmaline-muscovite-biotite granite containing from 72 to 75% silica.

The elvan dykes, of which there are at least two, and probably three, examples in East Pool, represent the later dyke phase of the granite magma. They all dip northward, and it is clear that they occupy fissures that were formed at the same time as those along which the main series of northerly dipping



lodes were afterwards developed. The general course of the elvans of the district is N58°E, which is also that of the "right running" lodes. From the fact that hardly any elvans dykes course N80°E (the strike of the other principal series of lode fissures), it seems probable that the latter set of fissures was formed much later than the former, and was for the most part subsequent to the period of elvan intrusion. Both series of fissures were, however, fully developed prior to the period of lode filling.

Lodes of East Pool.—These fall naturally into three series (1) north-dipping, (2) south-dipping, and (3) vertical. The foregoing classification is in order of decreasing importance and also of decreasing age.

(1) The members of the north-dipping series are:

(*a*) South lode and (its faulted continuation in depth) the Great lode, and a minor footwall member, the Red lode.

(*b*) Rogers lode, which is the downward continuation in the granite of the Dobree or North lodes (or of both) in the killas.

(2) The south-dipping series contains:

(*a*) New South lode,
(*b*) New Engine lode,
(*c*) New North lode with its faint footwall member (Bramwell lode).

These strike N. 65°–68° E. and dip south 65°–70°.

(3) The vertical series contains:

(*a*) Middle lode,
(*b*) Ginger Pop lode,
(*c*) Caunter lode.

There is no doubt that the Great lode is the downward continuation of the South lode, which has been faulted up by the New Engine and New South lode-fissures a distance of 30–35 fathoms. The problem of the further continuation of the Great lode below the 228 fathom level has always engaged the attention of the management. The veteran geologist, the late Mr. J. H. Collins, so long connected with East Pool, very reasonably concluded that the New North lode-fissure was a fault-fissure and that it had thrown up the Great lode precisely as the New Engine lode fault had thrown up the South lode, and he argued therefore that the faulted continuation of the Great lode would be found to the north well above the 265 fathom level.

On this assumption the 200 fathom north cross-cut was driven, and it was stopped only because a stream of water that threatened to drown the pumps was encountered. At that time there was no evidence whatever against Mr. Collins' assumption, and it was accepted as a very reasonable probability by the present writer when laying out the exploration work in conjunction with Captain Jennings in 1912. The existence of a north-dipping lode immediately to the north of the New Engine lode was at that time only vaguely known. The plans showed a short length of workings on it only to the 36 fathom level. But it was reasoned that the strong lode that extended through the east of Wheal Agar (Dobree lode, worked to 90 fathoms) and apparently connecting with a north lode in South Crofty, where it had been worked to a depth of 170 fathoms (Trevenson shaft), should also be found north of the New Engine lode, and further that this lode so strong in length would also persist in depth into the granite, where it might be expected to furnish a good tin lode. On this assumption, combined with the possibility of meeting the faulted portion of the Great lode, the north cross-cuts, which have resulted in the discovery of the Rogers lode, were driven.

It is curious to relate that no plan of East Pool subsequent to 1846 shows the deeper workings on the Dobree lode, nor was there any record available of the existence of the North and Trembath lodes. It was only by a thorough search, in January 1915, through plans prior to 1846, that it was realized how strong these lodes had been in the killas and to what an extent they had been worked by the old miners. This experience shows the prime importance to any company engaged in re-opening or developing Cornish mines of making a completely new set of plans embodying all the available information and, not less important, of collating and digesting all information contained in cost books, report books, mining journals, &c.

To return to the Great lode, the first evidence in disproof of the fault theory was the failure to find any trace whatever of the New North lode on the 160 fathom north cross-cut. Had this lode occupied so strong a fault-fissure as was necessitated by the requisite upthrow of at least 40 fathoms, it would certainly have been well defined on that level. Final proof of the absence of any material upthrow on the New North lode is afforded by the fact that nowhere on this side of the mine is the granite upthrown to the north. It may be reasonably assumed that the good ore found on the New North lode between the 228 and 265 fathom levels is due to the influence of contact with the Great lode. What then has become of the Great lode below this level? It is probable that it will yet be found in the foot-wall of the New North lode during the course of ordinary cross-cutting operations to develop the Rogers lode below the 240 fathom level.

The South (Great) lode has a long exposure on the surface. On the west it is the North Entral lode of Dolcoath and the North Tincroft of Tincroft, while to the east it is continued as the Barncoose lode of Carn Brea. It has therefore an outcrop of at least two miles.

The Rogers lode was first struck in the killas at the 160 fathom level and later in the granite at the 240 fathom level. Its strike is N70°E and its dip from the 160 to the 212 fathom levels 55°, and from thence to the 240 fathom level 73°. Its width and value are described in an appendix to this article. It has already been suggested that it is the downward continuation of one or more of the north-dipping series north of the New Engine lode (Dobree, North, and Trembath lodes). These were extensively worked for copper in the early years of the 19th century and were abandoned (the North lode at 140 fathoms) when they intersected the greenstone.

The New Engine lode and the New North lode both became very poor in depth, the former at 260 fathoms, the latter at 300 fathoms. The deepest working in the mine is on the latter lode at 343 fathoms (2,053 ft.) below adit level. The New Engine was a strong lode from the surface downward, but the New North lode was highly profitable only from the 228 to the 260 fathom level, where in all probability the enrichment was caused by the downward intersection of the Great lode. This enrichment of minor lodes by intersection with the Great lode is rendered apparent in the accompanying section, where similar enrichment is shown by the Caunter, Ginger Pop, and Middle lodes.

The characteristic feature of the vertical lodes is that they are essentially granitic lodes, which do not persist upward into the killas. An inspection of the section will also show that the best horizon for exploration for tin lodes at East Pool is 50 to 60 fathoms below the granite, a feature borne out by experience elsewhere (Dolcoath, &c.) in the Camborne-Redruth area.

It is highly probable that the stronger

north-dipping lodes of East Pool will carry tin ore to much greater depth than do the south-dipping lodes. The average depth of the zones of the latter, so far as they have been explored, is about 120 fathoms, while those of the north-dipping lodes should reach, if any reliance is to be placed on analogy with the other strong tin lodes of the district, about 300 fathoms below the bottom of the copper zone.

MINERALOGY.—A list of the more important economic minerals that have been found in the East Pool lodes is as follows: Cassiterite, wolfram, chalcopyrite, mispickel, bismuthinite, azurite, stannite, scheelite, fluor-spar, and some cobalt ore. In the Rogers lode at the 196 fathom level a remarkable secondary occurrence of scheelite developed along cleavage cracks and veins in wolfram has been recently noted. Apparently the same secondary development of scheelite occurred in the upper workings of the Great lode, for similar occurrences from the Great lode were described by Mr. J. H. Collins as long ago as 1878.

The wolfram zone occurs near the top of the tin zone. In the Great lode wolfram was most plentiful from the 140 to the 196 fathom levels, a solid branch of wolfram 4 ft. thick being encountered below the 140 fathom level. In the Rogers lode, so far as it has been explored, wolfram is most abundant on the 196 fathom level. In the latter lode, however, the top of the tin zone is some 25 to 30 fathoms lower than in the Great lode.

The downward succession of economic minerals at East Pool is roughly: copper ores from surface to 140 fathoms, wolfram from 140 to 200 fathoms, and tin from 140 to 340 fathoms (south-dipping lodes) and possibly to 450 fathoms (north-dipping lodes). It is impossible to ascribe this vertical succession of minerals to any other cause than to decreasing temperature of metalliferous solutions with approach to the surface. Were we able to see those uppermost portions of the lodes now removed by denudation, we would probably find that the copper zone was succeeded by a still higher blende and galena zone.

GENERAL.—The outlook for East Pool seems bright. Apart from the shoot now known there is the great probability of others of similar character being found further to the east in the Rogers lode, the probability of the present shoot extending to a much greater depth, and the possibility of the Great lode being found on further exploration, to say nothing of the steady supplies of ore to be found in the development of the longer known lodes.

It may not be out of place to utter here a word of caution. Not every lode in killas in Cornwall when followed down into the granite will yield tin ore, nor will every lode have the depth of tin ore shown by the stronger lodes of the Camborne-Redruth district. The location of metalliferous deposits has been governed (a) by the channels open at the time of deposition, and (b) by the temperature of the solutions. Hence in a fissure passing from granite to killas, if the temperature of solutions while in the granite remained too great, deposition had perforce to take place in the cooler killas. Thus the rich shoots of Wheal Vor lay in the killas, and the fissure yielded nothing in the granite. The rich deposits of Phœnix failed likewise in the underlying granite. Tresavean shoot lies entirely in the granite, and though its lower portion is now being worked at a depth of 440 fathoms for tin ore, it was a copper shoot down to the 300 fathom level. But one of the best examples of the unimportance of the country of the lode-fissure as governing the nature of the mineral deposited is afforded by the Dolcoath—Cook's Kitchen—Carn Brea lode, where the copper and tin zones meet at an average depth of 200 fathoms from the surface, that is, in the killas 20 fathoms above the granite in the Stray Park section of Dolcoath and in the granite 95 fathoms below the granite surface in Cook's Kitchen section. The average depth of the tin zone along this lode-channel so far as it is yet known is about 300 fathoms.

DEVELOPMENT OF ROGERS LODE

As an appendix to Dr. Malcolm Maclaren's article we give herewith an account of the development of the Rogers lode, illustrated by plan and cross-sections. The lode was first intersected in 1913 at 523 ft. N. 3 ft. W. of East Pool shaft by a cross-cut at the 160 fm. level. The small amount of driving immediately done proved the lode to be only about 4 ft. wide, and to average about 24 lb. of tin and wolfram per ton by vanning assay in that section. (All assays in these notes are the vanning assays of tin and wolfram combined). The next point of intersection was on the 240 fm. level, where the lode was exposed in 1914 at 792 ft. N. 289 ft. W. of the shaft, and gave the following values:

	lb. per ton.
First 5 ft. of lode	98
From 5 ft. to 8 ft.	16
From 8 ft. to 11 ft.	14
From 11 ft. to 13 ft.	22
From 13 ft. to 15 ft.	21
From 15 ft. to 18 ft.	12

Owing to the poor ventilation and the large quantity of water coming from the lode it was with the greatest difficulty that men were induced to remain at work and continue the development work at this level. The value of the ore disclosed, however, gave such encouragement that it was decided to extend cross-cuts to the lode at the 190 and 212 fm. levels. At the latter level the cross-cut reached the lode, toward the end of 1915, at 730 ft. N. 5 ft. E. of the shaft, where the ore disclosed averaged 45 lb. per ton over a width of 30 ft. At the 190 fm. level the lode was intersected about the middle of 1916, at 675 ft. N. 2 ft. E. where it averaged 336 lb. per ton over a width of 10 ft.

From the plan on page 251 it will be seen that the 190 and 212 fm. cross-cuts intersected the lode at points along the same vertical plane as the 160 fm. cross-cut, while the 240 fm. cross-cut struck the lode at a point about 300 ft. further west.

Upon the lode being cut at the 190, 212, and 240 fm. levels, the work of opening it by means of drives and rises was pushed forward with all speed. At the two former levels this was rapidly carried out, but progress was slow at the bottom level owing to the causes previously mentioned. All the levels have been now connected by rises, and consequently the ventilation has greatly improved, the working conditions at present being normal.

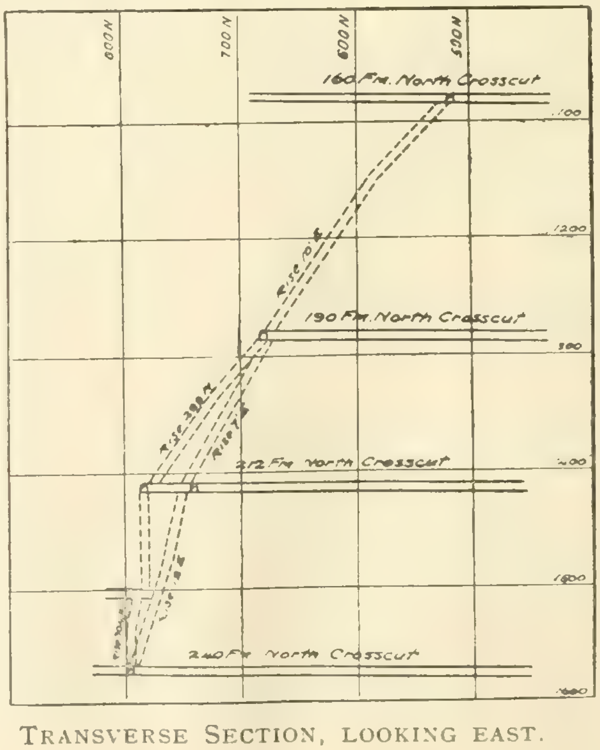
Below are given particulars of the development work so far carried out on this lode, and these can be clearly followed if reference is made to the plan and sections, on which the names of all the workings are shown.

On the 160 fm. level, the west drive has been advanced 158 ft., the ore for that distance averaging 24 lb. per ton over a width of 4·2 ft. The east drive has been driven 233 ft. in ore averaging 26·4 lb. per ton over an exposed width of 4·8 ft.

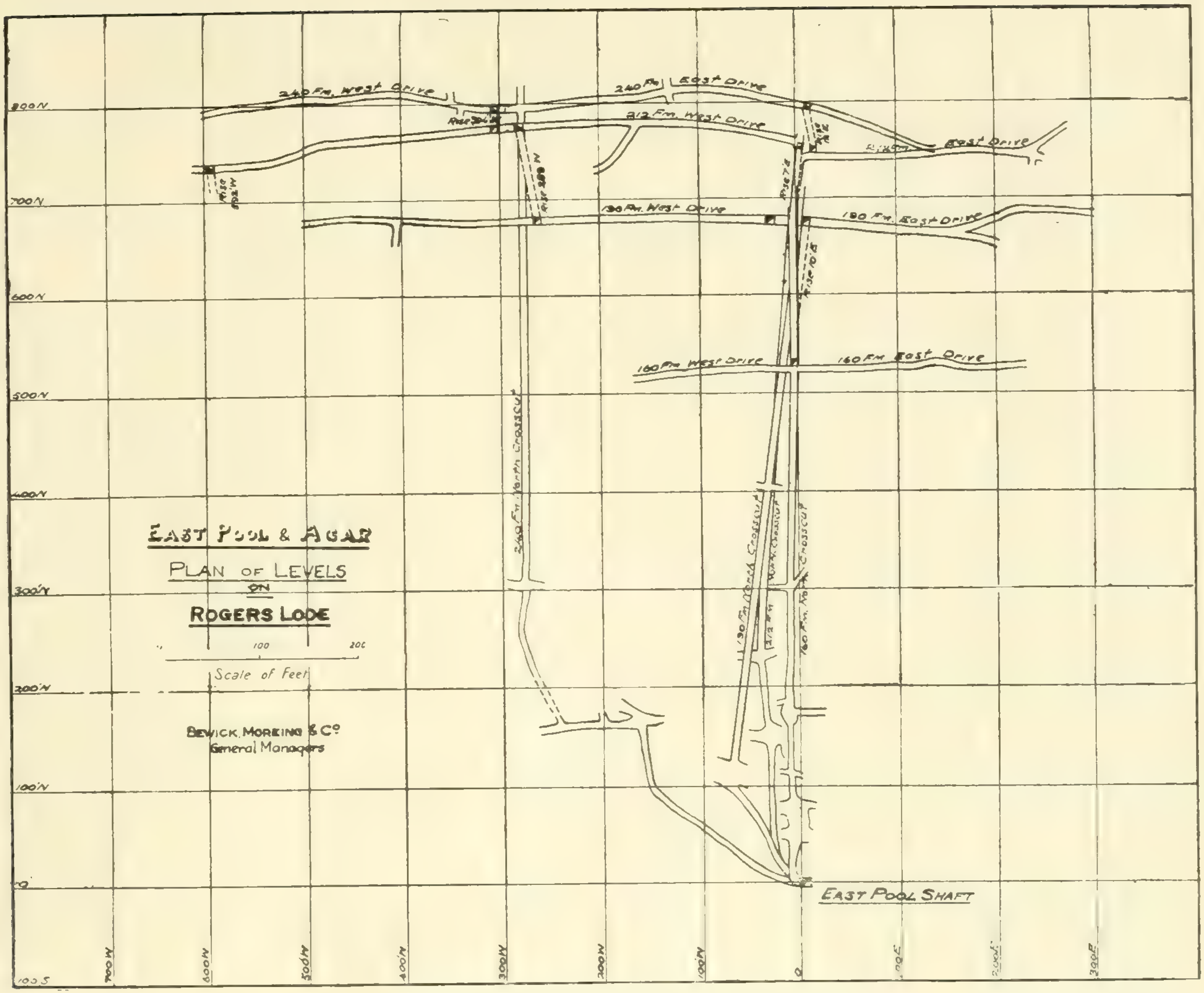
On the 190 fm. level, the west drive has been advanced 500 ft.; from 0 to 421 ft. the ore averaged 49 lb. per ton over a width of 5·7 ft. exposed, while the remainder was in low values. The east drive has been driven 308 ft. in ore averaging 131·2 lb. per ton over a width of 5·8 ft. exposed. The rise at 10 ft. E. was extended from the above drive and connected to the 160 fm. level. The ore disclosed for the distance of 247 ft. averaged 47·9 lb. per ton over a width of 4·1 ft. exposed.

On the 212 fm. level, the west drive has disclosed ore averaging 110·9 lb. per ton over a width of 5·9 ft. exposed, for the total distance of 625 ft. driven. The south cross-cut at 162 ft. W. off this drive disclosed a width of 48 ft. of ore averaging 57 lb. per ton. The full width of the lode was not exposed. The rise at 286 ft. W. was extended 165 ft. to the 190 fm. level in ore averaging 51·7 lb. per ton over an exposed width of 5 ft. The rise at 582 ft. W. has been extended 63 ft. in ore averaging 74·4 lb. per ton over a width of 7·2 ft. exposed. The east drive has been advanced 272 ft., the ore for this distance averaging 53·5 lb. per ton over an exposed width of 5·7 ft. The rise at 7 ft. E. was extended 147 ft., disclosing ore averaging 154 lb. per ton over a width of 5 ft. exposed.

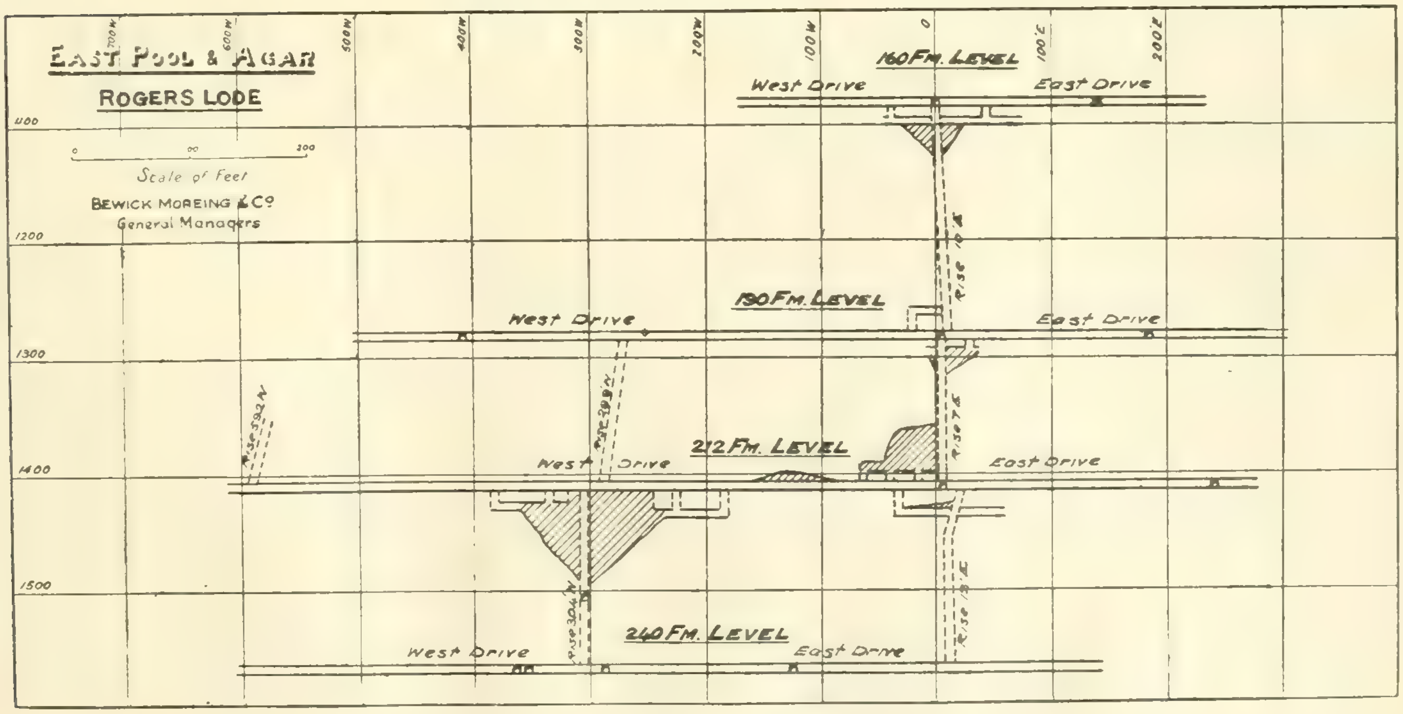
On the 240 fm. level, the west drive has disclosed ore averaging 67·0 lb. per ton over a width of 5·5 ft. exposed for the 322 ft. so far driven. The rise at 304 ft. W. from the above drive was extended 149 ft. to the 212 fm. level in ore averaging 100·2 lb. per ton over an exposed width of 5·9 ft. Intermediate cross-cuts off the above rise were extended at 65 ft. above the level, but did not expose the full width of the lode. The lode which was disclosed, however, averaged 79 lb. per ton over 19 ft. wide. The north cross-cut at 362 ft. W., started from the drive, was extended 9·5 ft. in ore averaging 65 lb. per ton, the face being in ore when the work was discontinued. The east drive has been advanced 442 ft., disclosing from 0 to 150 ft. ore averaging 48·1 lb. per ton over a width of 5·6 ft. exposed. The remainder of the drive was in low values. The rise at 12 ft. E. was started from the drive



TRANSVERSE SECTION, LOOKING EAST.



Plan of Levels on the Rogers Lode.



Longitudinal Section along the Rogers Lode, looking north.

and extended 136 ft. to the 212 fm. level, disclosing in the first 65 ft. ore averaging 18 lb. per ton over a width of 5 ft. exposed, and for the remaining 71 ft., ore averaging 67·5 lb. over an exposed width of 5·5 ft.

Stoping operations have been commenced on this lode, and are being extended as rapidly as conditions permit. The most important stope at present being worked is off the rise at 304 ft. W. from the 240 fm. level, and the ore so far extracted from this place has averaged 73 lb. per ton over a width of about 45 ft.

[The diamond-drilling campaign at East Pool also presents many features of interest. We refer to this subject in an Editorial.]

ESTIMATION OF TUNGSTEN IN PRESENCE OF PHOSPHORUS

By W. DEWAR, M.Inst.M.M.

THE following is a method of estimating WO_3 in scheelite ores containing phosphoric acid. It may be of use to others engaged in these examinations.

The quantity taken for analysis depends on the richness of the material to be tested. For poor mineral, 5 grammes may be taken. This is treated in a flat platinum basin or crucible with a mixture of 10 cubic centimetres of hydrofluoric acid and 2 c.c. of sulphuric acid in order to drive off silica. With ore containing 40 to 50% SiO_2 this amount of HF and acid must be used for each gramme taken. With rich mineral or concentrate above 50% WO_3 it is not necessary to treat with HF and acid. If sulphur is present, the ore is first roasted after weighing out for analysis. The HF mixture is added in three portions, evaporated slowly on a sandbath, stirring occasionally and carefully with a platinum wire. When the third addition has been evaporated, the heat is increased until the H_2SO_4 is driven off. If a direct flame is used the crucible should only be allowed to get slightly red. The residue is fused with 15 to 18 grammes of Na_2CO_3 and a little K_2CO_3 for about 20 minutes, and the contents occasionally shaken. The fusion is dissolved with distilled water in a suitable vessel, boiled for a few minutes, filtered and cooled, and transferred to a ½ litre flask and made up to the mark. As the residue is apt to contain small quantities of WO_3, it is advisable to fuse it a second time with Na_2CO_3 and join the two solutions. For mineral below 2% WO_3, 400 c.c. corresponding to 4 grammes of mineral are taken. If more than ½ litre is taken, the liquor is evaporated to 250 to 300 c.c. Neutralize slowly in a covered beaker with HNO_3, using litmus paper as an indictator, and take the usual precautions of finishing with dilute acid. Boil to drive off the CO_2, allow to cool, and precipitate the WO_3 and P_2O_5 by the addition of a neutral concentrated solution of $HgNO_3$. Heat to boiling, and continue for some minutes, and then filter. Wash the precipitate several times by decantation with a cold dilute solution of $HgNO_3$, and then transfer to the filter. Dry and separate the precipitate from the filter paper, burn, add a few drops of HNO_3 to oxidize the reduced portions, drive off acid, add the precipitate, and heat again, then weigh as $WO_3+P_2O_5$. The residue is fused with 12 to 15 times its weight of $NaCO_3$. The fusion is dissolved in distilled water, and HCl added until the solution is slightly acid. Boil and drive off CO_2, cool and neutralize with NH_4OH just to the neutral point, then add one-third of its volume of concentrated NH_4OH and 10 grammes of crystallized pure NH_4NO_3, and precipitate phosphorus with 30 to 50 c.c. of magnesia mixture as $MgNH_4PO_4$, allow to settle for about 12 hours and filter through a dense filter. Wash the precipitate with dilute NH_4OH until the filtrate made acid with HNO_3 gives no precipitate with $AgNO_3$. Then treat as usual, and calculate P_2O_5 in the burnt precipitate. The difference between $(WO_3+P_2O_5)$ and P_2O_5 gives the WO_3. As a check the WO_3 can be thrown down in the filtrate of the phosphorus precipitate, by boiling off all the NH_4OH contained, adding 5 c.c. of HNO_3 (1:4), and evaporating to dryness. Repeat this twice, each time adding 5 c.c. HNO_3. The last time evaporate on the water bath; these operations change the chlorides into nitrates. Dissolve in water—the solution should only be slightly acid—and precipitate as before described with $HgNO_3$, boil, filter, etc., and weigh as WO_3. In making the saturated solution of $HgNO_3$, and to facilitate the solution of the salt, 1 c.c. of HNO_3 is added per ½ litre, and as it is of great importance to have an absolutely neutral solution, a few globules of mercury are placed in the vessel in which it is stored. The dilute solution is prepared by adding 30 cubic centimetres of the strong solution to 100 c.c. of distilled water.

THE CONSTITUTION OF PYRITE
AND ALLIED MINERALS

By W. H. GOODCHILD, A.R.S.M., M.Inst.M.M.

Metallographic researches on alloys indicate that a better knowledge of the constitutions of ore minerals would throw much new and valuable light on the processes operative in the formation of ore deposits and on the relative distribution of their richer and poorer parts. The author briefly discusses a few of the commonest ore minerals from this viewpoint.

METALLURGISTS and geologists have been content hitherto to accept the chemical nomenclature of the current text-books of mineralogy, and to regard the constitutions of their ore minerals as properly represented by the supposedly molecular formulæ assigned to the various minerals in such works. As a result of my experience with various metallurgical processes, and particularly with studies of the geo-chemical processes whereby ore minerals are formed in nature, I have been led to the conclusion that the simple molecular constitutions usually assigned to the commoner ore minerals do not afford an adequate basis for interpreting the various chemical and physical phenomena presented, but that the unit systems are generally larger and more complex than is represented in mineralogical text-books. Little or nothing is at present known concerning the actual molecular constitutions of our common ore minerals, the text-book formulæ being of a purely empirical kind. If we are to obtain a more profound and detailed insight into the processes governing the formation of ore minerals in nature and the winning of the metals therefrom under industrial conditions, a more precise knowledge of their constitutions is a matter of fundamental importance.

As a useful means of expressing quantitatively the main features of an apparently simple chemical reaction, the value of the ordinary chemical equation is beyond question, but its limitations are often overlooked. Consider, for example, the reaction in aqueous solution between copper sulphate and hydrogen sulphide. The equation is usually written thus:

$$Cu\,SO_4 + H_2S = H_2SO_4 + CuS$$

and is commonly interpreted thus: one molecule of H_2S reacts with one molecule of $Cu\,SO_4$ to produce one molecule of CuS and one molecule of H_2SO_4. It is forgotten that nothing of the kind has ever been observed, but only the final results of interaction between vast numbers of units, while in this case the products are made in the presence of a preponderating quantity of another substance. It is a far cry from the single molecule of cupric sulphide as represented in the equation by a pair of united atoms to the aggregates of copper sulphide precipitate actually observed, while the events that transpire in building up these aggregates are to a large extent wrapped in obscurity. Moreover the cupric sulphide precipitate is always accompanied by variable amounts of cuprous sulphide, so that this simple equation does not even satisfactorily explain the ultimate composition of the precipitate.

The same kind of reasoning applies to the problem of the constitutions of the common ore minerals and the processes of ore formation. Although it is not possible at present to determine definitely the molecular weights, volumes, and constitutions of our ore minerals, signs are not wanting that such determinations may before long come within the scope of practical physical chemistry. Meantime there are a number of facts that indicate in a more or less qualitative manner that our ore minerals are not such simply constituted systems as they are commonly represented to be, and that this greater degree of complexity and variety of constitution is responsible for a number of phenomena that are otherwise without satisfactory explanation.

Pyrite is so widely distributed in nature and is such a common constituent of ore deposits that it is of special interest in this connection both to the metallurgist and the mining geologist. It is usually represented by the formula FeS_2, and consequently as a molecule built of three atoms. It is typical of a large class of natural sulphide minerals which have the chemical property that when heated to moderate temperatures they undergo more or less complete dissociation into a simpler sulphide, or matte constituent, and free elemental sulphur. A consideration of this reaction is a convenient starting point for a discussion of the constitution or degree of complexity of the pyrite system. As sulphur is a constituent of both products of this reaction, and is common to the whole class of compounds of which pyrite and the lower sulphide, or iron matte, may be considered as the fundamental types, it is pertinent to the question to review as briefly as possible some of its physical and chemical characteristics. These characteristics are striking, and the element is in many ways peculiar.

Elemental sulphur at a temperature of 2,000° C. and at atmospheric pressure contains one atom in the molecule. Between 800° C. and 2,000° C. the gas molecules are mainly composed of two atoms each. As the temperature falls from about 800° C. to the boiling point, 448° C., the vapour density of the gas increases by the gradual increase of the proportion of more complex molecules. This increase in density is generally represented by the equation $S_2 \rightleftarrows S_8$, until at the boiling point the vapour consists entirely of molecules containing 8 atoms. The melting phenomena are again of an unusual kind. Common orthorhombic sulphur has a density given by various authorities at figures ranging from 2·03 to 2·075, and it melts at 114° C., a temperature not much above the boiling point of water, to a thin mobile amber-coloured liquid. On raising the temperature the colour of the fluid changes to a darker hue, and it gradually loses much of its mobility, until between about 220° C. and 250° C. it becomes so viscous that the vessel containing it may be inverted momentarily without spilling the sulphur. With a further increase of temperature to 300° C. the viscosity diminishes, but the molten mass does not again become so mobile over the temperature range between 300° C. and the boiling point. Quenching from 300° C. or thereabouts by pouring into cold water produces a plastic jelly-like substance, plastic sulphur, which is metastable and passes slowly to the crystalline state. It has been shown experimentally that melted sulphur is at least a two-phase and probably a three-phase system. It was previously noted that the molecule of sulphur vapour at the boiling point contained 8 atoms, while generally speaking the tendency of gas molecules is to be simpler in constitution than the fluid or solid phases of the same substance. These remarkable melting phenomena are known to be due not merely to a high degree of molecular association, but to the interaction of systems of differently constituted complex molecules, of which there are at least two and probably more than two types. It presents indeed a striking similarity to certain "transient colloids." Another feature of this element is the relatively large number of allotropic forms, again indicating both molecular complexity and variety of molecular type. When dissolved in suitable solvents it still retains a high degree of molecular association. Dissolved in carbon disulphide, for instance, the molecule contains 8 atoms, while the liquid carbon disulphide molecule itself appears to contain no less than 32 atoms of sulphur*, a point of no small interest in this connection.

Experiments carried out at the Carnegie Institute at Washington indicate that the pyrrhotites are solid solutions of sulphur in ferrous sulphide, and from general chemical considerations this view appears to be well founded. There seems to be no ground for believing that any serious decrease in the degree of association of the element is brought about by solution in ferrous sulphide, but on the contrary, analogy renders it highly probable that the pyrrhotites contain dissolved sulphur in the form of highly associated molecules. This view is supported by consideration of the densities of the pyrrhotites and other "higher" sulphides of iron. The synthetic pyrrhotites prepared at Washington do not appear to be absolutely identical in constitution with the naturally occurring minerals, the latter apparently being of higher specific gravity for a corresponding composition. It was noted at Washington that as the quantity of dissolved sulphur increased the density of the resulting pyrrhotite diminished, whereas the opposite appears to be the case for the natural minerals, as far as can be judged from published analyses. Hitherto little attention has been given to the comparative study of the relative densities of the natural sulphides and other ore minerals as a means of elucidating the problems of their molecular constitutions and the processes connected with their formation. The comparative investigation of densities has shown itself to be one of the highest importance in the development of our knowledge of molecular chemistry, and has already yielded so many and such brilliant results in theoretical chemistry that it would appear to be worthy of more serious consideration in connection with the study of minerals and the processes whereby minerals are formed under natural conditions.

A simple method of analysing some of the volume relations of the natural sulphides, and

*T. Holmes, Journal of the Chem. Soc., Vols. CIII. and CIV. Contributions to the Theory of Solutions, p. 2147 et seq.

one that brings out some interesting and suggestive features, is to calculate the diminutions in volume that occur as the result of combination of the elements or compounds and to express the contraction in terms of sulphur density. For instance, the difference between the solid specific volume of natural FeS and that of pyrite may be considered as approximately the volume occupied by the additional sulphur, and from this its density may be calculated. The assumption is that the matte constituent of the system, FeS, is closely compacted and of negligible compressibility, an assumption that is probably not very wide of the mark in view of its density, and its specular and metal-like characteristics, the last two properties especially indicating a close packing of the molecules of the substance. The density of the sulphur dissolved in the synthetic pyrrhotites prepared at Washington, according to this method of computation, is roughly 2·5, or about equal to that of sulphur in chalcocite or covellite; whereas in the natural pyrrhotites it appears to be about 6, or approximately three times as dense as common orthorhombic sulphur and identical with that of the second portion of the sulphur in the pyrite system. Since diminution in volume or increase in density is so frequently a result of polymerization, it seems probable that the natural pyrrhotites contain dissolved sulphur polymerized to a degree similar to that of the second portion of sulphur in the pyrite system, and greater than in the case of the synthetic preparations. There is an important experimental fact that indicates, though not perhaps conclusively, that the natural pyrrhotites are not, as might be inferred from this density relationship, solid solutions of pyrite in troilite or FeS, for, using the commonly accepted terminology, without prejudice to the fundamental point of this discussion, the disulphide of iron, or pyrite, is insoluble in hydrochloric acid, whereas the pyrrhotites are easily attacked by this reagent, leaving a residue not of pyrite but of sulphur.

The natural pyrrhotites and the synthetic products thus appear to be identical to the extent that both are apparently of the nature of solid solutions of sulphur in ferrous sulphide, although the differences in density point to differences in the molecular condition of the dissolved sulphur. On the other hand, the state of the sulphur in the natural pyrrhotites would appear from the density relationship to be similar to that of the second portion of sulphur in pyrite. The very large contraction in volume that occurs when pyrite is formed from FeS by the addition of sulphur is particularly noteworthy, as it appears to be altogether exceptional when compared with the corresponding phenomena presented by other natural sulphides. A cubic centimetre of pyrite contains a greater weight of sulphur than a cubic contimetre of solid orthorhombic sulphur, a fact that does not seem to have attracted particular attention hitherto. Pyrite thus appears to be a natural device for cramming the maximum quantity of sulphur into the minimum of space, and from this point of view it is of special geological interest.

A summary review of the density relationships of sulphur, the pyrrhotites, and pyrite, taken in conjunction with the collateral chemical evidence, thus leads directly to the conclusion that they are all highly associated and molecularly complex substances, and that such simple formulæ as FeS_2, Fe_7 S_8, etc., do not represent their true molecular constitutions but only fractions of these. Consequently the molecular volumes are very much greater than would appear from a consideration of the commonly accepted formulae for these mineral systems, such as are given in text-books of mineralogy. It will be shown later that many other natural sulphide minerals of economic importance appear to be similarly constituted. The relatively large size and complexity of the unit systems of these sulphides is of immediate geo-chemical interest and significance in connection with the processes of their precipitation from such dilute solutions as are thought to be operative in the concentration of the useful metals into ore deposits. It suggests, for instance, how porosity of a rock may conduce to local precipitation from a solution by the ultrafiltration of the smaller molecules of a solvent such as water from bulky molecules such as these sulphide systems appear to be.

From the geo-chemical standpoint, water, with or without the addition of such gases as carbon dioxide, oxygen, sulphuretted hydrogen, etc., is the solvent of most general interest. It is evident from what is known of the degrees of association of these substances that their molecules would be quite small in size as compared with the molecular volumes indicated above for the sulphides of iron and similarly constituted minerals.

The slow formation of a visible crystalline precipitate from a dilute solution opens up a vista of physical and chemical operations concerning which we know but little. That it is a continuous diminution in the degree of dispersion is beyond doubt, but in the case of the building of a crystal of a substance such as can be represented by a general empirical formula FeS_2, several alternative lines of procedure are possible.

The splitting of a synthetic reaction into stages is a recognized means of ascertaining both the intrinsic constitution of a substance and its possible modes of formation. The formation of pyrite, or of marcasite, under natural conditions is not uncommonly due to the slow interaction of sulphuretted hydrogen in very dilute iron-bearing solutions. If a solution of an iron salt be fairly rapidly precipitated by an excess of sulphuretted hydrogen, the product of the reaction is not a disulphide of iron, but relatively large aggregates of the mono-sulphide, despite the presence of a sufficiency of sulphur to form the higher sulphide. We may infer therefore from the foregoing piece of experimental evidence that the first reaction that occurs in the formation of pyrite from a dilute solution is not merely the formation of single molecules of the mono-sulphide of iron, but something more than this, namely, the preliminary formation of aggregates of ferrous sulphide as a disperse phase in the solution, that is to say, in the language of colloid chemistry, ferrous sulphide sol. The influence of relative concentrations, velocity, etc., of this part of the precipitation of iron sulphide from a dilute solution may thus have an important bearing on the composition of the final product. A well known property of sols is their capacity for adsorption of suitable substances in virtue of their surface energy. If the conditions are such that the first step in the reaction is conducted at such a high velocity that relatively large aggregates of the lower sulphide are produced at a rapid rate, the ratio of mass to surface is liable to be so seriously increased that any further reaction depending on the surface energy of the first product will tend to be eliminated or suppressed. That sulphur should dissolve in ferrous sulphide or be adsorbed by ferrous sulphide sol is not only probable on general theoretical grounds but is well founded on specific experiments. Sulphuretted hydrogen, even under the most favourable conditions for its existence as such, is but a weak combination of sulphur and hydrogen, while in dilute aqueous solution it may be regarded as practically entirely dissociated.

Under suitable conditions therefore small disperse ferrous sulphide aggregates would be presented with the additional sulphur in a form suitable for adsorption, while on the other hand pyrrhotite, instead of pyrite or marcasite, might be the sole or principal end product if the velocity of the preliminary reaction were too high for the second reaction to proceed to any great extent. It follows from a general consideration of the phenomena presented by the surface layer of dilute solutions that solution and adsorption of one substance in or by another are closely related phenomena. In the case of adsorption in the surface layer of a solution the principal difference is one of concentration of the solute in the solvent consequent on the special conditions prevailing in the surface layer. This is a point that should not be overlooked in connection with the constitution and possible modes of formation of such substances as pyrite and marcasite under natural conditions. It seems permissible to regard these substances almost indifferently as either a special type of solid solutions, or adsorption compounds, since at higher temperatures, accompanied by adequate external pressure, the extra sulphur would in all probability dissolve in the matte constituent of the system to form the more complex sulphides, pyrite or marcasite, the external pressure, coupled possibly with fluidity of the matte constituent of the system, playing a similar part in inducing combination or solution as the surface energy of the disperse lower sulphide aggregates produced in a relatively cool dilute solution. The intimate relationship between intrinsic pressure and surface tension should not be overlooked in this connection.

Pyrite more than marcasite is a mineral that is formed over a very wide range of temperature and pressure under natural conditions, and is one of the minerals classed as "persistent" by Lindgren. It would be mere presumption to assume that it has been invariably precipitated from a cool weak solution, so that whatever view may be held as to the constitution of the mineral it must be compatible with the field evidence. The existence of the polymorphic forms of the "higher" sulphides of iron, pyrite and marcasite, is capable of a simple explanation on the hypothesis that the second portion of sulphur in the two systems is in a different allotropic state. Although both forms have high densities according to the method of density analysis previously outlined, and extensive polymerization is presumably common to both, there is this very interesting and suggestive relationship between the respective densities of pyrite and marcasite on the one hand, and those of the two commonest allotropic varieties of sulphur on the other, namely, the orthorhombic and monoclinic forms. The ratio of the density of pyrite to that of marcasite is practically identical with the ratio of the density of orthorhombic sulphur to that of the monoclinic, and is approximately 1·03. The ease with which marcasite decomposes under weathering influences and the far greater stability of pyrite under like conditions become readily intelligible if the second portion of sulphur in marcasite is in the state that is metastable at ordinary atmospheric temperatures, as is indicated by this density relationship. Again, the ease with which the pyrrhotites weather in comparison with pyrite, which, it is significant to note, is one of the most difficult of all sulphides to decompose by weathering influences, may likewise be due to the influence of the additional highly compressed or polymerized sulphur in the stable state contained in the latter, the pyrrhotites being "unsaturated" compounds.

The world-wide occurrence of gold in intimate and preferential association with pyrite also appears susceptible of explanation. Ferrous sulphide is known to be an active solvent for gold and in fact for most of the common metallic sulphides. It thus seems chemically probable that suspensoid ferrous sulphide would tend to precipitate gold from a weak gold-bearing solution by adsorption either of the metal or its sulphide from such a solution. The saturation of the suspensoid ferrous sulphide with sulphur to form either pyrite or marcasite would almost assuredly bring about the precipitation of the gold on the well known principle of the "common ion," the end result being pyrite or marcasite crystals enclosing particles of metallic gold. It can also be calculated from physical properties of ferrous sulphide or pyrrhotite, and pyrite respectively, that the adsorption is of negative sign, and that consequently the tendency would be for the adsorbed gold to be driven toward the exterior of the growing pyrite or marcasite crystals. The rounded marcasite aggregates of the Rand with little flakes of gold attached to their peripheries are noteworthy in this connection. In the case of the great complex zinc-lead deposits of the refractory type in which the individual sulphide crystals are small and closely interwoven, the iron sulphide mineral, if present in fairly large quantity, as is usually the case, is pyrrhotite. Since both lead and zinc sulphide are soluble to some extent in ferrous sulphide, the fine grained character of the sulphides and the matte-like structure of the masses of mixed sulphides suggests that in the absence of sufficient sulphur to form pyrite, or conditions unfavourable to the formation of pyrite, thus rendering the other sulphides insoluble in the iron sulphide, the development of large well individualized crystals of the lead and zinc sulphides may be impeded, and a fine grained felted mass of mixed sulphides precipitated. The fact that most primary zinc blendes contain ferrous sulphide is also a matter of interest in this connection.

As an example of another type of mineral constitution arsenopyrite is of interest. It would appear from density considerations to be a solid solution or alloy of the löllingite and pyrite systems formed by the union of these two types of molecule without further contraction. It seems certain therefore that its real constitution is something quite different from FeAsS, as is so often represented, while its molecular volume must be correspondingly large. Many other minerals consisting of mixed sulphides and arsenides or antimonides appear to be similarly constituted and to present striking similarities to alloys.

Pyrite, marcasite, and arsenopyrite are examples of minerals characterized by great contraction in volume by the union of their atomic constituents, that is to say, they are relatively high-density minerals. Chalcopyrite presents a striking contrast, for its density is lower than a mechanical mixture of cuprous and ferrous sulphides with sulphur in similar proportion ; in other words chemical union is accompanied by increase in volume. This is intelligible on the basis of an equilibrium between the respective attractions of the two competing sulphides of copper and iron for additional sulphur being established in the system by partial breaking down or dissociation of the extra sulphur. This explanation, however, can only apply on the hypothesis that the chalcopyrite unit system or molecule is of a more complex type than is usually represented. It is noteworthy in connection with the formation of chalcopyrite under natural conditions that it is always the last mineral to crystallize in the magmatic ore deposits formed in basic magmas, the accompanying and earlier formed sulphides being of a kind that undergo little or no dissociation by heating in a mattrass.

In the domain of metallurgy a great deal of useful work has been accomplished in recent years by the application of metallographic and other physico-chemical methods to the study of industrial alloys. In geology, petrographic and metallographic methods have increased our knowledge of mineral deposition, but at the same time these methods have greatly widened the outlook and made evident many other problems concerning which they are unable to give much enlightenment. Concurrently with these and kindred researches much evidence has accumulated indicating that many of the physical and chemical properties of the elements and compounds depend primarily on the space occupied by their atoms and molecules, and that this space or volume factor not improbably has an even greater influence on their general properties and deportment than atomic weight. The general solution of many of the problems arising as a result of petrographic and metallographic studies would appear to be by way of the extension of physico-chemical science, and particularly in the sense of wider knowledge of the molecular constitutions and volumes of the substances concerned.

Now the molecules of most metals, even in the solid state, are believed to be either monatomic or to contain but a small number of atoms. The multi-atomic or highly associated character of the different types of sulphur molecule is in striking contrast with that of the metallic elements. Many of the natural sulphides, however, closely resemble metals and alloys in certain respects, while at the same time exhibiting equally important differences in others. The union of metallic elements, characterized by molecular simplicity, with an element such as sulphur, characterized by great molecular complexity and variety, may be expected to give rise to compounds of special interest in connection with properties arising from or dependent upon the space occupied by the molecules of such systems. It would appear, therefore, that a largely unexplored but fruitful field for research by the aid of physico-chemical methods is presented in the study of the natural sulphides, arsenides, antimonides, tellurides, etc., or in other words, the various ore minerals. It seems not improbable that extended investigations of these substances on such lines would on the one hand shed useful light on many of the obscure problems connected with the properties of alloys, and on the other facilitate the interpretation of the structures and relationships made manifest by the application of petrographic and metallographic methods to the study of ore deposits.

The principal object of these observations is to draw the attention of metallurgists and geologists to the unsatisfactory state of knowledge in regard to the fundamental constitutions of the ore minerals from which the world's supply of base metals is derived, and at the same time to suggest that research by the aid of physico-chemical methods in connection therewith would find ample justification not merely as a scientific pursuit but as a matter with far reaching economic possibilities.

The Ontario Nickel Commission.

The Report of the Ontario Nickel Commission is a bulky volume of over 600 pages, accompanied by many illustrations and maps, and constitutes one of the most valuable technological monographs ever written. In the summary of the conclusions of the commissioners, Messrs. G. T. Holloway, Willet G. Miller, T. W. Gibson, and McGregor Young, it is stated that nickel can be economically refined in Ontario, and that the Ontario nickel deposits can compete successfully with those of any other country. Particulars are given of the various mines and of the operating companies. Of the latter the International and the Mond companies are already sufficiently well known. The new company, with which Messrs. W. A. Carlyle and E. P. Mathewson are connected, is the British America Nickel Corporation, a company controlled and largely financed by the British Government. This company owns the Murray, Whistle, and other mines at Sudbury. The refinery will probably be erected at the Murray mine, and the process employed will be the electrolytic method used by Hybinette in Norway. This method is adapted for a country where sources of cheap hydro-electric power are plentiful, and it has the advantage of recovering the rare metals accompanying the ores. The proportions of these metals which the ores carry are minute and vary in the several deposits. Roasted matte from one of the companies showed 0·1235 oz. platinum, and 0·197 oz. palladium, 0·027 gold, and 1·84 oz. silver, while the other company's matte showed platinum 0·988 oz., palladium 0·984 oz., gold 0·256 oz., and silver 6·155 oz. per ton. Both platinum and palladium are now worth at least five times as much per ounce as gold. The International Company's refining process recovers a much smaller quantity of the precious metals than the Mond and electrolytic processes. The production of nickel as a by-product was also investigated by the Commission. By-product nickel comes mainly from the electrolytic refining of blister copper, copper ores almost invariably carrying a small proportion of nickel.

DISCUSSION

Mining in China.

The Editor:

Sir—The papers by Messrs. Way & Robertson in your July and November issues are interesting as supplementing the somewhat fragmentary information on the geology of Sze-chuan. Mr. Robertson's observations are particularly useful, as the region dealt with appears to have been missed by Bailey Willis and Blackwelder, whose geological work deals with Northern Sze-chuan. Logan Jack's "Back Blocks of China" contains a good deal of interesting information on the region, though it is a little out of date. Leclère, Lantenois, and Rocher deal more especially with Yunnan. It is to be hoped that further data of scientific value may be available as a result of the visit of the Standard Oil engineers to Sze-chuan. Their work may throw light on Mr. Coggin Brown's theory of possible relation of the salt-bearing Red Basin of Sze-chuan, described by Mr. Way as of Triassic Age, to the Permo-Triassic deposits of Yunnan. This relation may assume great economic importance in view of recent discoveries.

When Mr. Coggin Brown deals with the records of the Mining Bureau, he refers no doubt to the Provincial Capital and Magistracy records, such as were kept in the Yamens in pre-republican days. Such records were drawn up by officials having no knowledge of mining, and, when translated without careful editing, have assisted, as Mr. Coggin Brown implies, in propagating the altogether erroneous ideas as to the mineral wealth of China which are held by foreigners and by the great majority of Chinese. At the same time, the laborious mining records existing throughout China in local archives are of distinct value to the miner. They are accurate as to dates, and the main facts of history, but prove of little technical value, because the official recorders did not enjoy such little scientific knowledge as was known to the old miners and smelters. It must not be expected, for instance, that the ancient Chinese considered four of the five "elementary" metals, silver, tin, copper, and lead, to be less forms of gold than nine-tenths of the Chinese actually believe them to be to-day. Moreover, the Chinese language at the present time is little more flexible than the written characters, which for all practical purposes entered the fossil stage two thousand years ago. Modern science is expressed in China by Japanese now-a-days.

Mr. Way appears to refer to the Mining Bureaus which were started as a result of the division of China into eight Mining Districts after promulgation of the 1914 Mining Regulations. The "Gold" or "Metal Mining Bureau" (the Chinese character for "gold" is the same as that for "metal") was started in 1915, as a result of the whim of a Minister of Finance who was under the impression that China could secure gold cheaper by mining it herself than by purchase in the open market. This bureau has, fortunately, now been abolished, but Provincial Bureaus continue to give object lessons of the futility of State mining in China. You suggest in your editorial that eventually the deposits of the south-western Chinese Provinces will come prominently before the public. Eventually no doubt they will do so. The two articles published indicate the two or three districts which are standing the test of actual production. Such districts as have hitherto come before the public in both Sze-chuan and Yunnan have, I believe, proved disappointing to the mining engineer, as much on account of their poverty in mineral wealth as on the score of the impossibility of their being profitably worked either by Chinese or foreign capital under existing conditions.

William F. Collins,
A.R.S.M., M.Inst.M.M.

Peking, January 22.

Wolfram in Cornwall.

The Editor:

Sir—The production of wolfram in Cornwall, and, to a small extent, Devon, was I believe about 300 tons in 1916. For the preceding 20 years or thereabouts, the total annual production has not averaged 200 tons, and this amount has been almost exclusively obtained in the shape of a small by-product from three of the Redruth-Camborne tin mines: East Pool, South Crofty, and Tincroft. From the last two the extraction in the mill has been, I think, about 3 lb. per long ton crushed. The almost negligible balance (of the 200 tons mentioned) has come from certain alluvial properties in the north-eastern and other sections of Cornwall and from the south-west of Devon.

With one solitary exception, the property now being developed under the writer's direction near Scorrier has been the only lode mine ever developed in the West of England for wolfram alone. The exception noted is that of an adjoining property, Wheal Gorland, which a few years since was worked in a very small way with a production varying between 3 and 7 tons of high-grade concentrate monthly.

That the foregoing facts are as stated is but another example of the proverbial neglect of home resources by both the business community and the Government; the neglect being particularly notorious in the case of those who could and did find capital in almost endless amount for foreign enterprise, but who could do nothing at all for the opportunities at their own doorstep. That this is the case should be well demonstrated when, within a few months, one property now approaching the producing stage will be turning out nearly as much wolfram concentrate as the whole 200 tons above named.

The point, however, of this brief statement is to insist that, with the judicious expenditure of a comparatively moderate sum—moderate as compared with the National interests involved in the production of tungsten—Cornwall and South-West Devon could well turn out 1,200 to 1,500 tons of concentrate yearly; or up to five times the past year's maximum production. Furthermore, as to at least 1,000 to 1,200 tons of this total, it would come, not as a small by-product from the tin mines, but as the sole or certainly major and most valuable product of wolfram-bearing and other tungsten-ore deposits, which might be expected to show yields of 20 to 25 or more pounds of wolfram, plus a little tin, per ton crushed. After nearly two years' careful and extended investigation upon the spot, I could name half-a-dozen districts in Cornwall and Devon where several promising and quite shallow properties are available upon easy terms, and where depth and water (the twin curses of Cornish mining) do *not* off-set the advantages of good-sized, well mineralized, and payable lodes. With the expenditure of say £250,000 spread over a dozen such properties, carefully selected, there should be many "winners," the joint output from which should easily total the 1,200 tons or more per annum spoken of.

Now as to cost and profit. The type of mine I allude to should in no case call for a capital outlay of more than £20,000 to £25,000, and should produce a concentrate at an outside cost of £80 to £90 per ton, leaving, at the present price of £180, more than an equal sum as net profit; at which figure, too, there remains a generous margin for any possible post-war fall in the price of wolfram.

A. SPENCER CRAGOE.

London, April 20.

The Literature of China-Clay.

The Editor:

Sir—In the Mining Digest at the end of your April number you reproduce practically in full the admirable paper of Mr. J. M. Coon on the development of mechanical appliances in china-clay works, which you preface by remarking that the literature relating to china-clay is not extensive. You then go on to mention an article published by Mr. J. H. Collins in the Magazine for June 1911, and the monograph published by the Geological Survey in 1915, but you make no reference to the pioneer work on the subject published by Mr. J. H. Collins so long ago as 1878, under the title of the "Hensbarrow Granite District." This book has been extensively quoted from and utilized by every subsequent writer on the subject, including the author of the Survey Memoir referred to. As the early Collins monograph upon the subject, now unfortunately out of print, is looked upon in all scientific and local circles as a classic, it seems a pity that no mention should be made of it in your remarks upon the subject.

H. F. COLLINS.

Crinnis, Cornwall, April 19.

[Any bibliography of china-clay should, of course, include a reference to the late Mr. Collins' book on the Hensbarrow Granite District. Our note attached to Mr. Coon's paper related only to recent publications that are still in print.—EDITOR.]

PERSONAL.

R. S. BLACK, manager of the Kalgurli mine, has been elected president of the Australasian Institute of Mining Engineers.

W. B. BLYTH and F. A. MARRIOTT have entered into partnership, with offices at Bulawayo.

F. O'D. BOURKE has left on his return to the Naraguta tin mine, Nigeria.

L. N. B. BULLOCK has been promoted to the rank of Major in the Canadian Engineers.

J. MORGAN CLEMENTS is being sent by the Bureau of Foreign and Domestic Commerce, of Washington, to investigate the mineral resources of the Far East, including China and Siberia.

W. F. COLLINS, manager of the Filani mine, is here from Nigeria.

FRANCIS DRAKE is in Paris.

CHARLES GREENWAY, chairman and managing director of the Anglo-Persian Oil Company, is the new president of the Institution of Petroleum Technologists.

T. R. HAMBER has left for Nigeria.

HENRY HAY has returned from Chile to the United States.

H. C. HOOVER has been appointed Food Controller for the United States and left London for New York on April 21.

JOHN M. ILES has recently made an examination of the Geevor tin mine, Cornwall.

CLARENCE J. INDER, of the firm of Inder, Henderson, & Dixon, has left for the Ropp Tin company's property, Naraguta, Nigeria.

J. IRVINE JAMESON left London last month on his return to the Leeuwport tin mine, Transvaal.

W. J. KING is here from Jantar, Nigeria.

A. F. KUEHN has returned from the Bawdwin mines by way of the United States.

FREDRICK LAIST, manager of the Anaconda smelter, has gone to Chile.

ANDREW LAMBERTON has been awarded the Bessemer Medal of the Iron and Steel Institute in recognition of his work in connection with the rolling-mill.

J. DYER LEWIS has been appointed Divisional Inspector of Mines for the South Wales Division, in succession to W. N. Atkinson, resigned.

ARTHUR LLEWELLYN, of the staff of John Taylor & Sons, has returned from a visit to Egypt.

JOHN C. MCLENNAN, professor of physics in the University of Toronto, has been appointed a member of the British Board of Inventions.

H. E. NICHOLLS is home from Nigeria.

C. T. NICOLSON is on his way from America to Petrograd on business in connection with the erection of a Bucyrus dredge at the Lena goldfield.

WALTER G. PERKINS has opened an office in San Francisco.

EDGAR RICKARD has been conducting a campaign in Canada for the benefit of the Belgian Relief Fund, and he received hearty support from the Canadian Mining Institute.

A. TREVOR ROBERTS is here on leave from Nigeria.

J. A. T. ROBERTSON is now with the Missouri Cobalt Co., at Fredricktown, Missouri.

Lord SALVESEN has been appointed chairman of the Arizona Copper Company, Ltd.

FRED. SEARLS, Jr., has returned from China to the United States.

WILLIAM SELKIRK represents the Ministry of Munitions in the Cumberland district in connection with the plans for increasing the output of iron ore.

S. J. SPEAK has returned from Siberia.

M. WADA, of the Ashio copper mines, Japan, is visiting the United States.

H. R. VAN WAGENEN, of Denver, is in Chile.

L. L. WATERHOUSE has been appointed lecturer on geology in Sydney University.

ERNEST R. WOAKES has returned from a visit to the Argentine and Brazil.

HERBERT C. WOOLMER has gone to Russia.

W. K. D'ARCY died on May 2. He was one of the earliest shareholders in the Mount Morgan Company. In more recent years he took an interest in oil, and was a director of the Burma and Anglo-Persian oil companies.

DAVID H. BROWNE, metallurgist of the International Nickel Company, died suddenly last month at the early age of 52. He was for many years at the nickel-copper mines at Sudbury. His great contribution to technology was the successful application of coal-dust firing to the reverberatory furnace. It may be said of him that he was a gracious philosopher and a man of high public spirit.

LIEUTENANT CYRIL DOUGLAS MCCOURT was killed at the front recently. He was born in 1883, and was educated at the City and Guilds College. After serving for some time as chemist to the Morgan Crucible Co., he joined Professor W. A. Bone for the purpose of working out the application of the principle of surface combustion for steam-raising purposes. The "Bonecourt" boiler was the result.

METAL MARKETS

COPPER.—This metal has shown considerable weakness. Business is quiet all round so far as the open market is concerned. While the consumption is kept at a high level, this position has little influence on market prices, as supplies are mostly reaching consumers through the government departments interested. Standard copper has fallen from £136–£136. 10s. to £130–£130. 10s. for cash, and electrolytic from £151–£147 to £142–£138. The American quotation has dropped from 33¼–34c. to 28½–29½c. Sentiment in the United States is somewhat firmer, and a demand has latterly arisen for early delivery. The market however is quiet, as buyers are naturally reluctant to commit themselves while forward metal is offered at a considerable discount. Production is proceeding at a great pace, but the outlook is so obscure as to act as a deterrent to business.

Average prices of cash standard copper: April 1917, £134. 1s. 10d.; March 1917, £137. 1s. 2d.; April 1916, £124. 4s.

SPELTER.—The tone in this market is undecided, but on the whole inclines to lower levels. The future, however, is obscure. Japanese metal is being offered rather freely, but little encouragement is given to buy metal from Japan.

Average price of good ordinary brands: April 1917, £52. 18s. 11d.; March 1917, £54. 10s. 4d.; April 1916, £94. 1s. 8d.

TIN.—The market has been very strong and cash tin has risen from £216 to £231. The entry of the United States into hostilities has doubtless given the market its final impetus, but other factors have influenced the rise, chief among which is the strong statistical position. America has been consuming largely, and the visible supplies show a decrease of no less than 2,691 tons. At the same time shipments from Batavia have fallen off largely, as stocks held there are greatly depleted. The British Government is putting its face against any further rise in price, and it is probable that the steam has gone out of the market for the present. China has been offering rather more freely, but the rise in silver has prevented much business being done. Home consumers have bought moderately, and a fair business has been done on the Continent. English tin is in fair request at a good margin.

Average prices of spot standard tin: April 1917, £220. 3s. 10d.; March 1917, £207. 10s. 8d.; April 1916, £199. 10s.

LEAD.—There is no change in quotations. America is reported somewhat easier, but prices are far above English parity. Arrivals in this country in April were rather more free than of late, but some consumers are still in arrears and handicapped in their operations for want of suitable material.

Average prices of soft foreign lead: April 1917, £30; March 1917, £30; April 1916, £34. 8s.

NICKEL.—£225 per ton.

PLATINUM.—Price 290s. per oz.; scrap 260s. per oz.

QUICKSILVER.—Under control and daily prices suspended; general quotation £20 to £25 per flask of 75 lb.

BISMUTH.—11s. per lb. COBALT.—10s. per lb.

CADMIUM.—8s. per lb. CHROMIUM.—7s. 6d. per lb.

TUNGSTEN.—Wolfram and scheelite 55s. per unit, 65 to 70% WO_3. Tungsten powder 6s. 3d. per lb.; ferro-tungsten 5s. 6d.; prices based on 60s. per unit ore.

MOLYBDENITE.—90% MoS_2, 105s. per unit.

SILVER.—The price has gradually advanced once more, and at the beginning of May stood at the high level of the beginning of February, 38d. per ounce.

PRICES OF CHEMICALS. May 8

Owing to the war, buyers outside the controlled firms have a difficulty in securing supplies of many chemicals, and the prices they pay are often much higher than those quoted below.

		£	s.	d.
Acetic Acid, 40%	per cwt.	3	7	6
,, 60%	,,	4	15	0
,, Glacial	,,	9	10	0
Alum	per ton	15	0	0
Alumina, Sulphate of	,,	18	10	0
Ammonia, Anhydrous	per lb.		1	9
,, 0·880 solution	per ton	32	10	0
,, Chloride of, grey	per cwt.	1	18	0
,, ,, ,, pure	,,	3	10	0
,, Nitrate of	per ton	75	0	0
,, Phosphate of	,,	82	10	0
,, Sulphate of	,,	15	10	0
Arsenic, White	,,	70	0	0
Barium Chloride	,,	30	0	0
,, Carbonate	,,	10	0	0
,, Sulphate	,,	5	0	0
Bleaching Powder, 35% Cl.	,,	28	0	0
Borax	,,	37	0	0
Carbolic Acid, 60% Crude	per gal.		3	6
China Clay	per ton	1	10	0
Copper, Sulphate of	,,	62	0	0
Cyanide of Potassium, 98%	per lb.		1	0
,, ,, Sodium, 100%	,,			10
Hydrofluoric Acid	,,			6
Iodine	,,		11	4
Iron, Sulphate of	per ton	4	15	0
Lead, Acetate of, white	,,	95	0	0
,, Nitrate of	,,	65	0	0
,, Oxide of, Litharge	,,	42	0	0
,, White	,,	46	0	0
Magnesite, Calcined	,,	15	0	0
Magnesium Sulphate	,,	10	10	0
Oxalic Acid	per lb.		1	6
Phosphoric Acid	,,			10
Potassium Bichromate	,,		1	4
,, Carbonate	per ton	115	0	0
,, Chlorate	per lb.		2	6
,, Chloride 80%	per ton	65	0	0
,, Hydrate, (Caustic) 90%	,,	300	0	0
,, Nitrate	,,	75	0	0
,, Permanganate	per lb		12	6
,, Prussiate, Yellow (Ferricyanide)	,,		3	6
,, Sulphate, 90%	per ton	70	0	0
Sodium Metal	per lb		1	3
,, Acetate	per ton	72	0	0
,, Bicarbonate	,,	7	5	0
,, Carbonate (Soda Ash)	,,	7	0	0
,, ,, (Crystals)	,,	3	5	0
,, Hydrate, 76%	,,	24	0	0
,, Hyposulphite	,,	17	0	0
,, Nitrate, 95%	,,	23	10	0
,, Phosphate	,,	29	0	0
,, Silicate	,,	7	0	0
,, Sulphate (Salt-cake)	,,	2	2	6
,, ,, (Glauber's Salts)	,,	3	10	0
,, Sulphide	,,	23	0	0
Sulphur, Roll	,,	30	0	0
,, Flowers	,,	35	0	0
Sulphuric Acid, non-arsenical 140°T.	,,	4	5	0
,, non-arsenical 95%	,,	7	0	0
Superphosphate of Lime, 18%	,,	5	10	0
Tin Crystals	per lb.		1	6
Zinc Chloride, solution 100°T.	per ton	25	0	0
Zinc Sulphate	,,	25	0	0

STATISTICS.

Production of Gold in the Transvaal.

	Rand	Elsewhere	Total	Value
	Oz.	Oz.	Oz.	£
Year 1912	8,753,563	370,731	9,124,299	38,757,560
Year 1913	8,430,998	363,826	8,794,824	37,358,040
Year 1914	8,033,567	344,570	8,378,139	35,588,075
Year 1915	8,772,919	320,752	9,073,671	38,627,461
January 1916	759,852	27,615	787,467	3,344,948
February	727,346	26,248	753,594	3,201,063
March	768,714	27,975	796,689	3,384,121
April	728,399	26,273	754,672	3,205,643
May	751,198	26,483	777,681	3,303,377
June	735,194	26,570	761,764	3,235,767
July	733,485	27,602	761,487	3,232,891
August	752,940	28,210	781,150	3,318,116
September	744,881	26,686	771,567	3,277,408
October	764,489	27,850	792,339	3,365,642
November	756,370	26,696	783,066	3,326,253
December	748,491	25,971	774,462	3,289,705
Year 1916	8,971,359	324,179	9,295,538	39,484,934
January 1917	756,997	25,637	782,634	3,324,418
February	696,955	24,366	721,321	3,063,976
March	760,598	26,496	787,094	3,343,363

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
January 31, 1916	209,835	9,228	802	219,865
February 29	209,426	9,468	970	219,864
March 31	203,575	9,588	917	214,080
April 30	199,936	9,827	938	210,701
May 31	194,765	9,811	1,459	206,035
June 30	192,809	9,859	2,105	204,773
July 31	192,130	9,932	3,339	205,401
August 31	194,112	10,086	5,146	209,344
September 30	197,734	10,239	6,527	214,500
October 31	199,330	10,907	6,358	216,595
November 30	196,132	11,118	5,928	213,178
December 31	191,547	11,487	5,194	208,228
January 31, 1917	188,624	11,611	5,591	205,826
February 28	191,095	11,568	6,268	208,931
March 31	190,028	11,494	6,620	208,142

Cost and Profit on the Rand.

Compiled from official statistics published by the Transvaal Chamber of Mines. The profit available for dividends is about 60% of the working profit.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
Year 1912	25,486,361	29 2	19 3	9 11	12,678,095
Year 1913	25,628,432	27 9	17 11	9 6	12,189,105
Year 1914	25,701,954	26 6	17 1	9 0	11,553,697
Year 1915	28,314,539	26 3	17 5	8 5	11,931,062
July 1916	2,370,244	26 1	17 10	8 0	949,606
August	2,423,669	26 3	17 10	8 1	976,125
September	2,367,793	26 6	18 0	8 3	972,704
October	2,453,437	26 4	17 10	8 2	1,001,843
November	2,389,056	26 9	18 2	8 2	980,387
December	2,349,191	26 10	18 2	8 4	977,481
January 1917	2,337,066	26 10	18 8	7 11	941,520
February	2,153,691	27 3	19 2	7 10	841,259

Production of Gold in Rhodesia and West Africa.

	Rhodesia.		West Africa.	
	1916	1917	1916	1917
	£	£	£	£
January	318,586	296,113	140,579	131,665
February	313,769	289,734	137,739	104,892
March	335,368	300,183	150,987	158,727
April	339,386	...	135,976	...
May	323,783	...	132,976	...
June	333,070	...	127,107	...
July	322,365	...	128,574	...
August	338,001	...	125,143	...
September	322,035	...	127,138	...
October	325,608	...	132,577	...
November	317,135	...	130,101	...
December	306,205	...	146,409	...
Total	3,895,311	886,303	1,615,306	395,284

West Australian Gold Statistics.

	Reported for Export oz.	Delivered to Mint oz.	Total oz.	Total value £
January 1916	1,861	92,124	93,985	399,220
February	2,832	65,138	67,970	288,717
March	5,600	88,393	93,993	399,255
April	2,926	87,601	90,527	384,532
May	577	83,301	83,878	356,289
June	2,070	92,612	94,682	402,181
July	912	91,725	92,637	393,495
August	*	89,522	*	*
September	*	85,978	*	*
October	*	82,732	*	*
November	*	87,322	*	*
December	*	88,205	*	*
January 1917	*	83,962	*	*
February	*	81,810	*	*
March	*	76,171	*	*
April	*	82,144	*	*

* By direction of the Federal Government the export figures will not be published until further notice.

Australian Gold Returns.

	Victoria.		Queensland.		New South Wales	
	1916	1917	1916	1917	1916	1917
	£	£	£	£	£	£
January	89,900	...	66,700	50,150	39,000	29,000
February	76,500	...	79,050	63,200	30,000	26,000
March	103,600	...	76,920	61,200	36,000	41,000
April	60,000	...	83,300	...	63,000	...
May	119,500	...	116,230	...	19,000	...
June	86,000	...	72,200	...	18,000	...
July	100,600	...	85,400	...	23,000	...
August	66,800	...	86,000	...	24,000	...
Septem.	115,100	...	65,450	...	32,000	...
October	81,400	...	74,800	...	32,000	...
Novem.	94,000	...	60,300	...	31,000	...
Decem.	96,600	...	73,550	...	111,000	...
Total	1,090,000	...	940,500	174,500	459,000	95,000

Production of Gold in India.

	1914	1915	1916	1917
	£	£	£	£
January	193,140	201,255	192,150	190,047
February	185,508	195,970	183,264	180,904
March	191,853	194,350	186,475	189,618
April	189,197	196,747	192,208	...
May	193,031	199,786	193,604	...
June	192,224	197,447	192,469	...
July	195,137	197,056	191,404	...
August	196,560	197,984	192,784	...
September	195,843	195,952	192,330	...
October	198,191	195,531	191,502	...
November	197,699	192,714	192,298	...
December	211,911	204,590	205,164	...
Total	2,340,259	2,366,457	2,299,568	560,569

Daily London Metal Prices

Copper, Lead, Zinc, Tin, in £ per long ton. Silver in pence per standard ounce.

	Copper			Lead	Zinc	Tin	Silver
	Standard	Electrolytic	Best Select'd			Standard	
April	£	£	£	£ s.	£ s.	£ s. d.	d.
10	136	151	149	30 10	55 0	216 5 0	36 5/8
11	136	151	149	30 10	55 0	216 10 0	36 5/8
12	136	151	149	30 10	57 0	216 10 0	36 5/8
13	136	151	149	30 10	57 0	217 0 0	36 9/16
16	136	149	147	30 10	57 0	217 10 0	36 9/16
17	135	147	145	30 10	57 0	217 10 0	36 9/16
18	135	147	145	30 10	57 0	218 0 0	36 3/4
19	133	145	143	30 10	57 0	219 0 0	37 1/16
20	133	145	143	30 10	54 0	219 10 0	37 3/16
23	133	145	143	30 10	54 0	224 10 0	37
24	130	142	140	30 10	54 0	224 15 0	37 3/16
25	130	142	140	30 10	54 0	225 10 0	37 5/16
26	130	142	140	30 10	54 0	228 10 0	37 5/16
27	130	142	140	30 10	54 0	230 5 0	37 5/16
28	130	142	140	30 10	54 0	229 10 0	37 15/16
May.							
1	130	142	140	30 10	54 0	230 0 0	37 3/4
2	130	142	140	30 10	54 0	229 10 0	37 7/8
3	130	142	140	30 10	54 0	229 10 0	38 1/8
4	130	142	140	30 10	54 0	230 15 0	38 1/8
7	130	142	140	30 10	54 0	231 15 0	37 15/16
8	130	142	140	30 10	54 0	232 10 0	37 15/16

Imports of Ores and Metals into United Kingdom.

These figures do not include Government imports.

Long tons.

	Year 1916	Feb. 1917	March 1917	Year 1917
	Tons	Tons	Tons	Tons
Iron Ore	6,905,936	507,560	494,188	1,513,552
Copper Ore	34,492	1,687	1,717	5,353
,, Matte and Precipitate	43,839	1,247	1,973	5,311
,, Metal	111,412	7,016	7 142	22,139
Copper and Iron Pyrite	951,206	86,920	70,758	249,678
Tin Concentrate	33,912	6,499	2,641	10,610
,, Metal	33,646	2,193	2,765	7,171
Manganese Ore	439,509	29,767	35,879	97,693
Lead, Pig and Sheet	157,985	10,087	7,127	29,143
Zinc (spelter)	53,324	4,150	3,691	14,799
	lb.	lb.	lb.	lb.
Quicksilver	2,556,214	2,800	15,100	64,944

Exports of Copper from United States

Reported every month by the United States Customs.

1916	Long tons	1916	Long tons	1917	Long tons
January	21,863	July	35,048	January	25,540
February	20,548	August	34,700	February	24,937
March	24,006	September	28,572	March	—
April	19,980	October	32,712	April	—
May	14,700	November	21,433	May	—
June	38,277	December	21,438	June	—
		Total 1916	313,277	Total 1917	50,477

Outputs of Tin Mining Companies.

In Tons of Concentrate.

	Year 1916	Jan. 1917	Feb. 1917	Mar. 1917
	Tons	Tons	Tons	Tons
Bisichi (Nigeria)	473	40	32	30
Briseis (Tasmania)	467	34	30	33
Dolcoath (Cornwall)	1,076	60	62	68
East Pool (Cornwall)*	1,012	88	87	94
Gopeng (F.M.S.)	1,113	92	76	73
Malayan Tin (F M.S.)	1,104	65	62	59
Mongu (Nigeria)	576	60	60	60
Naraguta (Nigeria)	523	48	44	40
N. N. Bauchi (Nigeria)	578	45	40	45
Pahang (F.M.S.)	2,591	220	220	220
Rayfield (Nigeria)	658	50	50	50
Renong (Siam)	894	82	61	73
Siamese Tin (Siam)	906	81	73	75
South Crofty (Cornwall)*	700	55	55	59
Tekka-Taiping (F.M.S.)	651	47	30	30
Tongkah Harbour (Siam)	1,135	96	87	147
Tronoh (F.M.S.)	1,662	108	83	76

* Including Wolfram.

Stocks of Tin.

Reported by A. Strauss & Co. Long tons.

	Feb. 28, 1917	Mar. 31, 1917	April 30 1917
	Tons	Tons	Tons
Straits and Australian, Spot	907	1,735	2,758
Ditto, Landing and in Transit	2,020	1,245	879
Other Standard, Spot and Landing	995	694	401
Straits, Afloat	5,994	5,314	3,845
Australian, Afloat	450	425	325
Banca, on Warrants	—	—	—
Ditto, Afloat	1,918	3,738	3,130
Billiton, Spot	—	—	—
Ditto, Afloat	100	117	100
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	1,613	1,121	1,535
Afloat for United States	3,625	3,455	3,835
Stock in America	3,027	3,362	1,707
Total Stock	20,649	21,206	18,515

Shipments and Imports of Tin

Reported by A. Strauss & Co. Long tons.

—	Year 1916	April 1917	Total 1917
	Tons	Tons	Tons
Shipments from:			
Straits to U.K.	27,157	1,470	9,839
Straits to America	25,943	1,745	7,018
Straits to Continent	8,487	1,178	3,740
Australia to U.K.	2,537	—	349
U.K., Holland, and Continent to America	14,863	1,075	5,415
Imports of China Tin into U.K. and America	1,305	—	5
Imports of Bolivian Tin into Europe	15,116	1,113	5,647
Deliveries in U.K.	16,862	1,634	3,390
,, ,, Holland	943	83	371

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1912	1913	1914	1915	1916	1917
	Tons	Tons	Tons	Tons	Tons	Tons
January	204	466	485	417	531	648
February	240	427	469	358	528	627
March	247	510	502	418	547	640
April	141	430	482	444	486	...
May	144	360	480	357	536	...
June	121	321	460	373	510	...
July	140	357	432	455	506	...
August	201	406	228	438	498	...
September	196	422	289	442	535	...
October	256	480	272	511	584	...
November	340	446	283	467	679	...
December	310	478	326	533	654	...
Total	2,540	5,103	4,708	5,213	6,594	1,915

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters. Long Tons.

	1913	1914	1915	1916	1917
	Tons	Tons	Tons	Tons	Tons
January	4,121	4,983	4,395	4,316	3,558
February	3,823	3,555	3,780	3,372	2,755
March	3,562	3,839	3,653	3,696	3,286
April	4,066	4,087	3,619	3,177	3,251
May	4,319	4,135	3,823	3,729	...
June	3,993	4,303	4,048	3,435	...
July	4,245	4,582	3,544	3,517	...
August	4,620	3,591	4,046	3,732	...
September	4,379	3,623	3,932	3,636	...
October	4,409	3,908	3,797	3,681	...
November	3,976	4,085	4,059	3,635	...
December	4,614	4,351	4,071	3,945	...
	50,127	49,042	46,767	43,871	12,850

Sale of Tin Concentrate at Redruth Ticketings.

	Long tons	Value	Average
Year 1915	4,918	£448,362	£90 14 6
July 3, 1916	179	£17,477	£97 12 10
July 17	186½	£17,114	£91 15 4
July 31	172¼	£16,172	£93 17 8
August 14	166	£15,955	£96 2 4
August 28	180¼	£17,345	£96 4 8
September 11	184	£17,113	£93 0 2
September 25	166½	£15,980	£95 19 7
October 9	197	£19,443	£98 13 11
October 23	170	£17,167	£100 19 9
November 8	194½	£19,701	£101 5 10
November 20	172	£18,044	£104 18 2
December 4	160½	£16,588	£105 4 6
December 18	186¼	*	*
Total, 1916	4,668	£478,194	—
January 2, 1917	176	*	*
January 15	160¾	£16,681	£103 15 5
January 29	152	£16,095	£105 17 10
February 12	182¼	£20,649	£113 6 1
February 26	176¾	£19,700	£111 9 3
March 12	179	£20,468	£114 7 0
March 26	161¾	£19,875	£122 17 8
April 10	179	£22,024	£123 2 0
April 23	169	£21,429	£126 16 0

* Prices not published.

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	May 5, 1916 £ s. d.	May 4, 1917 £ s. d.
RAND:		
Bantjes	15 0	7 6
Brakpan	3 17 0	5 1 6
Central Mining (£8)	6 5 0	6 6 3
Cinderella	6 6	4 3
City & Suburban (£4)	1 15 0	1 13 9
City Deep	3 18 0	4 7 6
Consolidated Gold Fields	1 7 6	1 11 3
Consolidated Langlaagte	1 13 6	1 7 0
Consolidated Main Reef	19 3	17 0
Consolidated Mines Selection (10s).	16 9	1 4 6
Crown Mines (10s.)	2 15 0	2 13 0
Daggafontein	15 9	13 6
D. Roodepoort Deep	14 6	11 3
East Rand Proprietary	14 6	11 0
Ferreira Deep	1 16 3	1 3 9
Geduld	2 6 6	2 2 6
Geldenhuis Deep	1 2 6	1 2 6
Gov't Gold Mining Areas	1 14 6	3 1 6
Heriot	2 12 6	2 2 6
Jupiter	7 3	6 6
Kleinfontein	1 9 9	1 3 0
Knight Central	14 9	9 6
Knight's Deep	1 2 6	1 0 0
Langlaagte Estate	1 0 0	16 6
Luipaard's Vlei	9 0	6 6
Main Reef West	8 0	4 9
Meyer & Charlton	5 8 9	5 6 3
Modderfontein (£4)	16 10 0	20 10 0
Modderfontein B	6 7 6	7 15 0
Modder Deep	6 5 0	7 6 3
Nourse	16 3	1 3 0
Rand Mines (5s.)	3 7 6	3 7 6
Rand Selection Corporation	3 5 6	3 15 0
Randfontein Central	11 3	14 0
Robinson (£5)	1 0 0	15 0
Robinson Deep	1 0 0	1 11 3
Rose Deep	1 5 0	1 0 6
Simmer & Jack	7 6	5 9
Simmer Deep	2 0	4 6
Springs	2 15 0	3 1 3
Van Ryn	2 6 3	1 18 9
Van Ryn Deep	3 5 0	3 6 3
Village Deep	1 12 0	1 6 3
Village Main Reef	1 0 0	15 0
Witwatersrand (Knight's)	2 15 0	2 2 6
Witwatersrand Deep	1 3 9	16 6
Wolhuter	11 0	10 6
OTHER TRANSVAAL GOLD MINES:		
Glynn's Lydenburg	11 3	15 0
Sheba (5s.)	2 3	1 3
Transvaal Gold Mining Estates	1 5 0	17 0
DIAMONDS IN SOUTH AFRICA:		
De Beers Deferred (£2 10s.)	10 5 0	13 2 6
Jagersfontein	3 6 3	4 6 3
Premier Deferred (2s. 6d.)	5 0 0	7 10 0
RHODESIA:		
Cam & Motor	17 0	8 6
Chartered British South Africa	10 6	12 9
Eldorado	10 9	8 3
Falcon	12 0	14 9
Gaika	12 0	8 6
Giant	7 6	5 6
Globe & Phœnix (5s.)	1 3 6	1 11 3
Lonely Reef	1 5 6	1 3 3
Shamva	1 15 6	1 5 0
Wanderer (3s.)	1 0	2 0
Willoughby's (10s.)	5 0	5 6
WEST AFRICA:		
Abbontiakoon (10s.)	7 6	5 0
Abosso	9 6	9 6
Ashanti (4s.)	18 9	19 6
Prestea Block A	9 6	6 0
Taquah	19 3	17 6
WEST AUSTRALIA:		
Associated Gold Mines	5 0	3 0
Associated Northern Blocks	3 3	2 9
Bullfinch	4 9	2 3
Golden Horse-Shoe (£5)	1 16 3	2 1 3
Great Boulder Proprietary (2s.)	13 0	10 9
Great Boulder Perseverance	1 6	1 0
Great Fingall (10s).	2 3	1 0
Ivanhoe (£5)	2 3 9	2 3 9
Kalgurli	12 0	8 9
Sons of Gwalia	14 9	14 0

GOLD, SILVER, *cont.*	May 5, 1916 £ s. d.	May 4, 1917 £ s. d.
OTHERS IN AUSTRALASIA:		
Mount Boppy, New South Wales	13 0	6 0
Talisman, New Zealand	12 6	12 6
Waihi, New Zealand	1 15 0	1 15 0
Waihi Grand Junction, New Z'lnd	19 3	15 0
AMERICA:		
Alaska Treadwell (£5), Alaska	6 10 0	1 15 0
Buena Tierra, Mexico	13 9	10 0
Camp Bird, Colorado	11 0	7 3
Casey Cobalt, Ontario	8 9	6 0
El Oro, Mexico	11 0	9 0
Esperanza, Mexico	12 0	10 9
Frontino & Bolivia, Colombia	9 6	11 6
Le Roi No. 2 (£5), British Columbia	10 0	7 6
Mexico Mines of El Oro, Mexico	4 1 3	4 0 0
Oroville Dredging, California	17 0	15 6
Plymouth Consolidated, California	1 3 0	1 1 0
St. John del Rey, Brazil	15 9	15 6
Santa Gertrudis, Mexico	14 9	10 6
Tomboy, Colorado	1 3 9	19 6
RUSSIA:		
Lena Goldfields	1 12 6	1 17 6
Orsk Priority	15 0	1 1 3
INDIA:		
Champion Reef (2s. 6d.)	8 3	5 9
Mysore (10s.)	3 18 9	3 2 6
Nundydroog (10s.)	1 7 0	1 5 6
Ooregum (10s.)	1 2 6	19 9
COPPER:		
Anaconda (£10), Montana	17 10 0	—
Arizona Copper (5s.), Arizona	1 17 6	2 8 0
Cape Copper (£2), Cape Province	4 3 9	4 5 0
Chillagoe (10s.), Queensland	6	3
Cordoba (5s.), Spain	4 6	3 0
Great Cobar (£5), N.S.W	3 3	2 3
Hampden Cloncurry, Queensland	2 2 6	1 14 0
Kyshtim, Russia	2 5 6	2 8 9
Messina (5s.), Transvaal	11 3	10 0
Mount Elliott (£5), Queensland	4 7 6	5 7 6
Mount Lyell, Tasmania	1 9 0	1 7 0
Mount Morgan, Queensland	2 4 6	1 15 6
Rio Tinto (£5), Spain	60 15 0	62 15 0
Sissert, Russia	18 9	1 5 6
Spassky, Russia	1 17 6	2 0 0
Tanalyk, Russia	2 0 0	2 2 6
Tanganyika, Congo and Rhodesia	1 18 9	3 2 6
Tharsis (£2), Spain	5 0 0	5 5 0
LEAD-ZINC:		
BROKEN HILL:		
Amalgamated Zinc	1 12 0	1 12 6
British Broken Hill	1 6 6	1 8 9
Broken Hill Proprietary (8s.)	2 18 9	2 7 3
Broken Hill Block 10 (£10)	1 3 9	1 3 9
Broken Hill North	2 8 9	2 10 0
Broken Hill South	8 2 6	8 5 0
Sulphide Corporation (15s.)	1 4 0	1 5 9
Zinc Corporation (10s.)	14 9	16 3
ASIA:		
Burma Corporation	2 5 6	4 1 3
Irtysh Corporation	1 19 6	2 2 0
Russian Mining	15 6	1 0 0
Russo-Asiatic	5 0 0	5 0 0
TIN:		
Aramayo Francke, Bolivia	1 6 3	1 12 6
Bisichi, Nigeria	8 6	14 0
Briseis, Tasmania	5 0	4 9
Dolcoath, Cornwall	9 9	10 0
East Pool, Cornwall	1 11 3	2 0 0
Ex-Lands Nigeria (2s.), Nigeria	1 9	2 0
Geevor (10s.) Cornwall	—	13 0
Gopeng, Malay	1 11 3	1 10 0
Ipoh Dredging, Malay	19 6	17 0
Malayan Tin Dredging, Malay	2 0 0	2 0 0
Mongu (10s.), Nigeria	9 0	15 3
Naraguta, Nigeria	17 6	15 0
N. N. Bauchi Pref. (10s.), Nigeria	6 3	9 9
Pahang Consolidated (5s.), Malay	10 0	11 3
Rayfield, Nigeria	6 6	8 0
Renong Dredging, Siam	1 10 0	2 5 0
Ropp (4s.), Nigeria	16 9	18 6
Siamese Tin, Siam	2 16 3	2 8 9
South Crofty (5s.), Cornwall	13 9	1 2 0
Tekka, Malay	3 0 0	3 0 0
Tekka-Taiping, Malay	2 5 0	2 17 6
Tronoh, Malay	2 1 3	1 7 6

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also reviews of new books, and abstracts of the yearly reports of mining companies.

THE PHOSPHATE DEPOSITS OF THE WORLD.

During March, Professor J. W. Gregory gave three lectures at the Royal Institution on "Geology and the War." The world's supply of phosphates was one of the subjects he discussed. We quote his remarks herewith. The first phosphatic fertilizer was ground bones, the use of which was first explained correctly early in the nineteenth century. Their manurial value had been attributed to their gelatinous material. A journal of 1830 states that as bones contain merely 2% of gelatine and "derive their fertilizing power from this substance only, they may be considered as having no value as manure." The Chinese were better informed; they had used bones as manure from time immemorial, and as they burnt the bones before using, they knew that the value was in the mineral matter of the ash. This conclusion was at length fully accepted in Europe after experiments by the Duke of Richmond in 1843 showed that bones from which the gelatine had been removed were equal in fertilizing power to fresh bones. The discovery of the agricultural value of the phosphoric acid in ground bones led to processes to improve their action. Thus Liebig in 1840, in a famous report to the British Association on the state of organic chemistry, recommended that to render bones more soluble they should be ground to powder and treated with sulphuric acid. This process had been independently adopted by Sir Gilbert Lawes, who was the first to put it into practice, for he had made soluble superphosphate and used it on his farm at Rothamsted in 1840. Lawes moreover made the still more important discovery that the mineral phosphates could be similarly utilized. He patented the process in 1842, established works to the east of London, and thus made England the first home of the superphosphate industry. England moreover yielded the first raw phosphates, which were mined from the nodule beds of Suffolk and the Cambridge Greensand. The optimistic Liebig declared that England had, in such deposits, a mineral equal in value to her coalfields. The world-wide search for phosphates has, however, led to their discovery in such large quantities in other countries, that the phosphate mines of England, Germany, and Canada have all closed. The supply now comes chiefly from five countries: the United States which in 1913 yielded 3,161,156 tons; Tunis and Algeria which yielded 2,750,000 metric tons; France which yielded 335,000 metric tons; Ocean and Nauru Islands in the West Pacific which yielded 300,000 metric tons in 1912; smaller quantities came from Belgium, which in 1913 yielded 219,420 metric tons; from Egypt which yielded 101,311 metric tons; and from Russia and various islands in the Pacific and Indian oceans. In 1913 the world's produce of phosphate rock was 6,888,000 tons; the United States produced 3,161,156 tons, of which 40% was exported to Europe. In addition 4 million tons of basic slag are annually produced in Europe (more than half in Germany) and used as phosphatic fertilizer.

The ultimate source of practically all our phosphorus is the apatite of igneous rocks; the amount of apatite in igneous rocks is 0·6 per cent. or 6 parts in 1,000, or 2½ parts of P_2O_5 per 1,000. From the igneous rocks the phosphoric acid is carried to the sea. where it is present in the minute quantity of 0·005% or 1 part in 20,000. It is removed from this water by various organisms, and thanks to them it is concentrated in beds rich enough to be of use to man. The geology of phosphorus is the story of the collection of the diffused apatite of the igneous rocks into beds and veins which supply the raw material of the phosphate industry.

The primary igneous phosphates are seldom of direct commerical value except as by-products, as from the mica mines which work the pegmatite veins of Canada. The chief phosphates of commercial value are of secondary origin and due to various organic processes. The first process is the conversion of small dead shells from carbonate of lime into phosphate of lime. These altered shells fall upon the sea floor, and as currents carry away the lighter calcareous material, the harder phosphatic particles accumulate as beds of phosphatic chalk or phosphatic limestone. The phosphatic grains thus formed are supplemented by the remains of crustacea and other organisms which form phosphatic shells and by teeth and bones of vertebrates. Thus are formed beds of phosphatic nodules such as the Cambridge Greensand. A third variety of marine phosphates consists of deep sea phosphatic nodules, which consist of sands and chalks cemented by phosphate, of foraminiferal oozes in which the shells have been altered into phosphate, and of material in which the phosphatization is so complete that the organic structures have been completely obliterated by concretionary phosphate.

The formation of guano is a process of phosphatic concentration which is completed on land. Minute animals and plants extract phosphorus from sea-water; they are the food of larger creatures, which in turn are thus eaten by others, and these fall a prey to fish. The phosphoric acid is gradually concentrated. The fish are devoured in their turn by sea-birds, which are very gluttonous. A bird weighing 6 lb. devours 3½ lb. of fish at a meal. According to Forbes the guano-producing birds of Peru each daily swallow 8 to 10 lb. of fish. The gluttony of these birds helps to save man from famine. The birds resort for safety during the nesting season to tropical islands where they live in vast flocks. The accumulation of their excrement forms the valuable manure guano. Guano is practically limited to small tropical islands off the western coasts of South America, South Africa, and Australia. The main supply is on the guano islands of South America which extend for about 1,000 miles along the coast of Peru and northern Chile. Birds inhabit these islands during the breeding season in myriads. They are sometimes as thick as there is standing room. On one small island Forbes estimated there were ten million birds. The birds resort to the islands for safety. On the mainland they would fall an easy prey to carnivorous animals, and their eggs would be taken by snakes and lizards. The consciousness of the birds of their danger was impressed on me in Spitzbergen, by a Norwegian walrus hunter who assured me that the birds on the off-lying islands do not lay their eggs until the last ice connection with the mainland is broken. They sit in rows along the cliffs watching until the last isthmus of ice is severed, and then, safe from the foxes, they at once waddle to their selected nesting place and lay their eggs. Guano therefore collects in large quantities only on small islets; they are restricted to a few coasts by meteorological factors. The nitrogenous compounds are easily soluble and quickly washed out by rain. Hence guano can only accumulate in an arid region, and rainless coasts are exceptional. Owing, however, to the cold current which flows northward along the western coasts of South America, South Africa, and Western Australia, parts of these coasts have very dry climates, and it is only under such conditions that nitrogenous guano can exist in quantities of commercial value.

Guano is a short lived product and its main contribution to the supply of fertilizers is as the parent of many rock-phosphates. The phosphoric acid dissolved from guano percolates into the underlying rocks and converts them into rock-phosphates. Fortunately in the regions where sea birds are most abundant many of the islands are raised coral reefs which are phosphated into phosphatic limestone. Where the bird accumulations take place on volcanic islands, the rocks are converted into phosphate of alumina. Thus the phosphate of Clipperton Atoll was found by Sir Jethro Teall to be an altered trachyte.

The warmer regions of the world supply the necessary association of raised coral reefs and innumerable sea birds; so these regions are the main home of phosphatic limestones. None of it is worked farther from the equator than the latitude of 50°, and the bulk of the supply comes from the tropics and sub-tropics; and owing to the conditions which control phosphate formation it is useless for the northern countries to expect to complete in the supply of raw material with tropical and sub-tropical zones. But we can gain the bulk of the profit by the manufacture of raw phosphate into phosphate manure.

The chief supplies of phosphate at the present time come from the vast deposits in the south-eastern states of America. The Florida phosphates are at present the most important. The phosphate region extends over 150 miles, 20 miles from the western coast. The phosphate deposits are of two chief types, beds of boulders that are sometimes a ton in weight in a matrix of clay, and rock-phosphate occupying hollows in the limestone. The phosphate has often slid down large slickensided surfaces, which show that the phosphate has sunk into hollows formed by the solution of the underlying limestones. The second type of Florida phosphate is known as "pebble phosphate." It consists of a bed of phosphate gravel, sometimes as much as 50 ft. thick. The Florida rock phosphate is attributed to the phosphatization of limestone from guano or from scattered grains in an overlying low-grade phosphatic limestone. The sporadic nature of the phosphate is strikingly similar to that of rock-phosphates formed in guano islands.

The phosphate of South Carolina was known in 1795 and was described by various geologists as marl. Its first recognition as phosphate was in 1859, and mining began in 1867. It is an irregular honeycombed mass, which has sometimes been broken in situ into nodules. The older theories, which regarded it as a seam of nodules collected by water, are untenable. It is explained as a residual soil formed by the disintegration of an overlying phosphatic clay, and then subsequently cemented into a continuous bed of phosphate containing about 50% of tri-calcic phosphate. The Tennessee phosphates include the largest reserves in the eastern United States. They at present yield about 40,000 tons per annum. The chief deposit is a friable rock known as "brown phosphate" which contains from 68 to 78% of tri-calcic phosphate. It was formed as a concentrate left by the solution of the underlying limestone; it sunk into solution hollows, and the limestone projects into bosses called "nigger heads," possibly from their hardness.

Vast reserves of phosphate in the world have been discovered in recent years along the Rocky Mountains. The phosphate rocks occur in a thick series of shales and limestones of Carboniferous age. The chief phosphate is a phosphatic oolitic limestone, and 75 ft. may yield on an average from 30 to 40% of tri-calcic phosphate. The field is estimated to contain 2,500,000,000 long tons of rock containing 70% of tri-calcic phosphate and four times as much lower-grade phosphate. The interesting problem connected with the origin of the Rocky Mountain phosphate is the cause of the concentration of this colossal amount of phosphoric acid. It was probably due to the concentration of phosphoric acid by the prolonged solution of limestone containing phosphatic grains after the elevation of the rocks above sea-level at the close of the Carboniferous age. The quantity of the phosphate is enormous. The material has not been worked, except to a small extent, for the local demand for fertilizers is insignificant, and it is too remote from the agricultural districts to pay for transport. It represents, however, a reserve of phosphate which will be of incalculable assistance to the west central states of America when they have reached a higher state of agricultural development.

The greatest reserves of phosphate in the Old World occur in the Eocene rocks of Algeria and Tunis. They extend through northern Algeria into Tunis, and end on the hills to the north of the vast salt lake, the Shottal Jerid. The phosphates are of two chief kinds, phosphate nodules in marl and phosphatic chalk. The known reserves of high-grade material are estimated at 300 million tons. The beds of phosphate are as much as 10 ft. thick, and several occur in the same section. Thus three beds are worked at Tebessa. In Southern Tunis are the great phosphate quarries of Gafsa, now the most productive single phosphate mine in the world. It contains four principal beds; the lowest is 10 ft. thick; the overlying bed is 6 ft. thick. By mixing the material from these two beds the product sold has an average of 60% tri-calcic phosphate. These North African phosphates were formed as granular deposits on the sea floor, which were concentrated by currents sweeping away the finer calcareous material. Further east, in Egypt, the valuable phosphate deposits found in the Cretaceous limestone to the west of the Red Sea near Kosseir. The Egyptian phosphate is shipped to Japan, as the high dues of the Suez Canal exclude it from Europe.

Passing to the European phosphates, they were the first worked, but are now relatively unimportant. Geologically the most interesting in Europe are the phosphates of the Somme along the line past Albert near Peronne and between the Somme and the Aisne. The phosphate occurs in lenticular sheets and bands of grey chalk charged with phosphatic grains, and also as sheets and layers which line pipes and rest in depressions in the chalk. Various suggestions have been made as to the origin of these phosphates. De Mercy, who knew them well, held that the phosphoric acid came up in thermal springs, since the distribution of the deposits coincides with the dominant crust fractures of the region. The phosphatic granules are often crystalline concretions which he identified as spherulites, and therefore as evidence of igneous action. De Mercy's case really depends on the distribution of the phosphatized masses. They occur along three parallel lines along the Authie, the Somme, and the Bresle. The valley system of this part of France was clearly determined by fractures formed during the uplift of the country; but the evidence is against the plutonic origin of the phosphate. The richest deposits, those near Doullens, were clearly concentrated by solution of the chalk and the subsidence of the relatively insoluble phosphatic grains into pipes and hollows.

The Russian phosphate fields are very extensive. The phosphate of Podolia along the Galician frontier and in Bessarabia ranges over 1,500 square miles, and the supplies are calculated at 80,000,000 tons; deposits also occur in an equal area, 1,500 square miles, in Bessarabia. In Central Russia are Cretaceous glauconitic sands containing 13 to 20% of phosphate. In the northern fields in the provinces of Vologda and Viatka, the phosphate contains about 36%. The total Russian output in 1913 was only 25,000 tons, and the eastern fields offer the best chance of commercial success since the Ural mines furnish supplies of pyrites, and sulphuric acid can be cheaply produced.

Owing to the vast output of phosphate cheaply produced in the southern fields, British phosphate mining ceased long ago. According to Fisher, the Cambridge district yielded phosphate of a gross value of £750 per acre; but the landowner drew £140 as royalty, and the miner had not only to remove all the earth above the ten-inch bed of phosphate but to replace it so as to leave the land as he found it. It did not pay to remove and replace the overburden, when it was more than 20 ft. thick, and Cambridge mining collapsed on the discovery of the richer American deposits. In 1876 the English output was a quarter of a million tons; three years later it had fallen to 30,000; in 1894 it was 700 tons, and it has now ceased altogether. Whether the industry can be revived or not remains to be seen.

LEAD SMELTING AT PORT PIRIE.

The Broken Hill Associated Smelters Proprietary, Limited, has issued a pamphlet describing the method of treatment of the Broken Hill silver-lead ore and concentrate as conducted at the Port Pirie smelting and refining works. The pamphlet was prepared for the purpose of explaining the company's exhibit at the Exhibition of Australian Primary Products and Manufactures held at Melbourne this year. As our readers are aware, the company treats the silver-lead output of Broken Hill. It was formed by the controllers of the North and South companies two years ago to take over the Port Pirie works of the Broken Hill Proprietary Company, and to conduct lead-smelting operations for the Broken Hill mines on a co-operative basis. The description of the processes given in the pamphlet is intended for the lay reader, but it is also of some interest to the metallurgist.

The lead concentrates treated contain on a average 60% lead, 20 to 25 oz. silver, and 15% sulphur. To make them amenable to smelting, they are first deprived of most of their sulphur contents. To effect this desulphurization two processes are used, the Dwight-Lloyd, and the Huntington-Herberlein.

In the Dwight-Lloyd process, the ore containing 14 to 15% sulphur is mixed with ground ironstone and limestone, and, after moistening with water, is charged on to a Dwight-Lloyd machine. This machine consists of a number of grates which are drawn over a vacuum chamber. The charge, having been ignited by means of an oil burner, passes over the vacuum chamber and becomes considerably reduced in sulphur contents by the air which passes downward through the mass combining with the sulphur to form sulphur dioxide, the latter being drawn away to the stack. The machine automatically discharges the roasted product on to a conveyor, from which it is delivered to rolls. The crushed charge is again moistened and fed to another similar machine, where the process is repeated. The resulting sintered product is then low enough in sulphur content for blast-furnace treatment.

In the Huntington-Heberlein method of treatment, the ore is fed with ironstone and limestone, as in the previous treatment, into Ropp roasting furnaces, which are 156 ft. long and 14 ft. wide. The charge is drawn along the furnace by automatic rakes, and the fire gases pass over it. The ore, after roasting, contains approximately the same percentage of sulphur as the material discharged from the first machine in the Dwight-Lloyd process. This roasted ore, while hot, is charged into converters holding 10 tons of roasted material, and air at a pressure of 1½ lb. is blown through the mass from the bottom. This treatment completes the desulphurization, and the sintered mass is tipped from the converters, broken, and delivered to blast-furnaces.

The essential differences between the Dwight-Lloyd process and the Huntington-Heberlein process is that in the former the ore is desulphurized and sintered by means of air being drawn down through it, while in the Huntington-Heberlein process the ore has first to be partly roasted in the Ropp furnaces and is then desulphurized by means of air forced through it from below. The tonnage of ore treated through both these plants is from 500 to 550 tons per day. The plant consists of 3 Ropp roasting furnaces, 20 pots, and 9 Dwight-Lloyd machines.

At the blast-furnaces the product from both desulphurizing processes is hoisted to bins on the smelter feed floor. The feed floor is also provided with bins for holding ironstone, limestone, coke, and slag. The limestone is supplied from the company's quarries at Point Turton and Wardang Island, situated in Spencer's Gulf; the coke from the company's coke works at Bellambi; while the ironstone is obtained from Iron Knob, owned by the Broken Hill Proprietary Company. The blast-furnace charge, consisting of roasted and sintered concentrates, ironstone, limestone, slag, and coke, is weighed on cars, which are run under the chutes of the bins, and are then hauled by cable over the throat of the blast-furnaces, into which they are dumped. The number of blast-furnaces in operation at the present time is three, which smelt on an average 1,200 tons of total charge per day, and produce 400 tons of base bullion. This bullion consists of lead containing 40 to 50 oz. of silver per ton, together with small quantities of impurities, principally copper, arsenic, and antimony. The blast-furnaces are 17 ft. long, 4 ft. 6 in. wide, and 25 ft. total height. They consume 22,000 cubic ft. of air per minute, which is supplied by turbine blowers. The amount of slag produced from these furnaces is approximately 750 tons per day; this slag, being worthless, is taken from the furnaces and tipped on the dump. In addition to the base bullion and slag produced, there is also a quantity of leady fume, which escapes from the throat of the furnaces. This fume is conducted by means of a fan to a house provided with flannel bags, these bags being 20 in. in diameter and about 30 ft. high. The fume is forced into these bags, which filter out the solid particles from the fume, the invisible gases passing out through stacks. These bags are shaken at intervals, when the fume falls into a chamber below the bag-house proper. This fume amounts to 20 to 25 tons per week, and is sufficiently rich in lead to warrant re-smelting.

The base bullion produced at the blast-furnaces is too impure to market. Moreover, as already stated, it contains considerable silver. The refining process has for its object the elimination of the impurities and the recovery of the silver. The base bullion is first charged into a drossing furnace, the main object of drossing being to remove copper. The copper in the original bullion amounts to 0·5%, while the copper in the dross removed runs as high as 10%. The dross produced on this furnace amounts approximately to 5% by weight of the bullion charged. The drossing operation consists in keeping this bullion melted. The dross, being lighter than the lead, rises to the top of the molten charge, and is skimmed off. After most of the copper has been removed, the bullion is tapped through cast iron launders into a softening furnace at a slightly lower level. The object of this softening furnace is to remove antimony and arsenic. The furnace is of the reverberatory type, with an approximate capacity of 65 tons, and is provided with a fire-box at one end. The arsenic and antimony are oxidized, and combine chemically with the oxide of lead to form a slag, containing 6 to 7% antimony, which is drawn off. This operation requires about 12 hours. The antimonial slag is charged into another reverberatory furnace with fine coal, resulting in a separation of metallic lead, the slag being left consequently richer in antimony. This slag, which now approximates 12 to 13% of antimony, is treated in a blast-furnace producing antimonial lead, commonly known as hard lead. This hard lead is the material from which shrapnel bullets, anti-friction metals, and type metals are produced.

The bullion in the antimony softening furnace, now freed from its impurities, is tapped into desilverization kettles. In addition to the silver contents, this bullion contains a small amount of gold. The extraction of both gold and silver is effected by means of zinc. A quantity of zinc is first added to the molten metal in the kettle and thoroughly incorporated with the bullion by a mechanical stirrer, and the bullion is then allowed to cool, thus causing the silver-lead-zinc-gold alloy to solidify and rise to the surface. This alloy contains all the gold and a little of the silver. The gold-bearing alloy is then set aside for treatment, as explained later. The kettle is again heated, and another addition of zinc is given to it to extract the bulk of the silver. The kettle is allowed to cool back as before. This alloy contains approximately 1,500 to 2,000 oz. of silver per ton, and is removed from the kettle into a pneumatic press, which squeezes out surplus lead. The alloy is put into bins for further treatment, to be explained later. The kettle is again fired strongly and more zinc added, which reduces the silver content to bullion of less than $\frac{4}{10}$ths of an oz. of silver per ton. This lead would now be pure except for the fact that it holds 0·5% of zinc. To remove this zinc, the lead is syphoned into a refining furnace, which is similar in every respect to the antimony softening furnace. The charge is here fired for 8 hours, and the zinc is oxidized and removed from the surface of the lead as a dross, which is returned to the blast-furnaces for the recovery of the lead contents. The lead is then tapped into a market kettle, from which it is syphoned into pigs weighing approximately one cwt. The analysis of the market lead shows: Antimony 0·006%, zinc 0·001%, copper 0·0001%, silver 0·0012%, and lead 99·9917%.

The silver-zinc-lead alloy, obtained after the second addition of zinc, is charged into plumbago retorts, placed in a gas-fired distillation furnace. Portable condensers are luted securely to the mouth of the retort, and the furnace is maintained at a temperature sufficiently high to distil off the zinc contained in the alloy. The condensed zinc is used again in desilverization kettles. When distillation of zinc is completed, the charge from the retorts is baled out into moulds, this bullion containing 2,500 oz. of silver per ton. It is then fed into a cupellation furnace, where it is concentrated to 16,000 oz. of silver per ton, or approximately 50%, by burning off the lead. This process is repeated until all traces of lead are driven off, and the silver is ladled out into bars of approximately 998·5 fineness. This silver is afterwards re-melted and alloyed with the necessary copper to reduce it to any required fineness that the buyers may require.

The gold-bearing alloy obtained after the first addition of zinc to the desilverization kettle is charged into a reverberatory furnace with litharge, derived from the cupels, the zinc in the alloy being oxidized and dissolved in the molten litharge to form a slag. This slag is drawn from the furnace and returned to the blast-furnaces for the recovery of lead and silver. The bullion, after being tapped from the furnace, is stored until sufficient is accumulated to fill the desilverization kettle. After melting down in the kettle, it is given an addition of zinc, and the gold is extracted as before, this treatment being the means of considerably concentrating the gold. This silver-lead-gold alloy is treated in distillation and cupelling furnaces for the production of doré bars containing 25 oz. of gold per 1,000 oz. of silver per ton. This doré is then charged into kettles, and dissolved in sulphuric acid. The silver sulphate solution is syphoned off and allowed to crystallize. The silver sulphate crystals are then reduced on a cupel with fine coal, and produce silver of 999·3 fineness. The gold remaining in the kettles is melted down with the addition of nitre and other fluxes, and cast into ingots weighing approximately 500 oz. This gold assays 99·2%.

The weekly production of the refinery plant is 2,400 tons of market lead and 125,000 oz. of silver.

As an example of the remarkable effectiveness of the refining process in eliminating impurities, the following analysis of a large tonnage of lead, in which a high degree of purity was required, may be of interest: Sb 0·000516%, Cu 0·00032%, Zn 0·000713%, Ag 0·000183%, Bi 0·00058%, Pb 99·997688%.

The pamphlet concludes with homely illustrations of the magnitude of the lead output at the Port Pirie plant. For instance the year's output of lead bars would reach twice the distance from Melbourne to Adelaide. Also if the bars were melted the metal would occupy a reservoir an acre in area and 9 ft. deep.

Australian Smelting Charges.—The Commonwealth and New South Wales Governments are investigating the treatment charges made by Australian smelting companies, more particularly in connection with silver-lead ores and concentrates and black copper and copper matte. E. C. Andrews, of the New South Wales Geological Survey, has made a report on this subject. He shows that small mines are hard hit by the high charges made for copper refining and the smelting of lead-silver concentrates, and he recommends that for the present these producers should have the option of exporting their output to England. Mr. Andrews refers to the present monopoly of two metallurgical companies, referring no doubt to the Electrolytic Refining & Smelting Co., at Port Kembla, and the Sulphide Corporation, at Newcastle. As far as lead-silver is concerned, the Broken Hill Associated deals solely with the output at that centre, and the only custom smelter available is the Sulphide Corporation. In this connection, the *Mining and Engineering Review* for February, in discussing this subject, prints a specimen tariff of the Sulphide Corporation, dealing with the purchase of Tasmanian lead-silver ores. We reproduce this herewith.

Quotations for Tasmanian Lead-Silver Ores. Delivery f.o.r.; in sound bags. Full dry lead (that is, wet assay less 1 unit) paid for at buyers' price of soft foreign lead, as per London Public Ledger. Full standard silver paid for.

The returning charge to be calculated as follows:

Lead % Wet Assay	For lots with 3 months' metal adjustment. Per ton. £ s. d.	For lots without adjustment of metal prices. Per ton. £ s. d.
25	5 5 0	5 17 6
30	5 12 6	6 7 6
40	6 7 6	7 7 6
50	7 2 6	8 7 6
60	7 17 6	9 7 6
65	8 5 0	9 17 6
70	8 12 6	10 7 6
75	9 0 0	10 17 6
80	9 7 6	11 7 6

Intermediate grades at proportionate rates.

The above returning charges are based on: (1) Ores carrying equal ounces of silver to units of lead per ton; (2) a lead price of £25 per ton.

They are subject to the following variations;

(1) For each full increase of 10% in the silver assay over equal units of lead per ton, the returning charge is to be increased at the rate of 0·22 pence per unit of lead contents. For instance:

Lead % Wet Assay	Silver assay oz.	Proportionate increase	Amount to be added to returning charge per ton.
65	65	—	—
65	71·5	10	1s. 2d.
65	78·9	20	2s. 5d.
65	84·5	30	3s. 7d.
50	55	19	11d.
50	110	120	11s. 0d.

No decrease in the returning charge can be allowed if the proportion of silver ounces is lower than the lead units.

(2) For each full £1 increase or decrease in the price of lead, above or below £25 per ton, the returning charge is to be increased or decreased by 0·4 pence per unit of lead in the ore. For instance:

Lead % Wet Assay	Price of lead	Increase or decrease per ton	Increase or decrease in returning charge per unit	Amount to be added or deducted from returning charge per ton
65	£27	£2	0·8d.	4s. 4d.
65	£26	£1	0·4d.	2s. 2d.
65	£25	—	—	—
65	£24	£1	0·4d.	2s. 2d.
65	£20	£5	2·0d.	10s. 1d.

For parcels of 5 tons and under, a sampling fee of 10s. will be charged. If the ore contains bismuth it will be necessary to penalize it at the rate of 6s. per pound and pro rata for each pound of bismuth contained per ton of ore.

As regards payment, if the seller elects to sell his ore without subsequent adjustment of metal prices, account sales will be made up and cheque sent out as soon after agreement of assays as possible. The metal prices will be based on the corporation's weekly telegram received for date immediately preceding sampling date. If the seller elects to sell his ore with subsequent adjustment of metal prices, provisional account sales will be made up on agreement of assays based on the above metal prices, and cheque sent less 25% of the net amount shown on the account sales; but these payments are to be considered as advances only, and are subject to adjustment on the average price of standard silver and soft foreign lead for the third calendar month following the calendar month of sampling. In computing these averages, the average daily price for standard silver, as per Sharps & Wilkins' circular, to be taken to the nearest 1-16d. per ounce, and the average buyers' price of soft foreign lead, as per the London Public Ledger, to be taken to the nearest 1d. per ton.

The usual conditions as to strikes, washaways, war, etc., to be agreed to.

Copper Resources of Arctic Canada.—The March *Bulletin* of the Canadian Mining Institute contains some notes by Mr. J. J. O'Neill on occurrences of native copper in the northern regions of Canada within the Arctic Circle. Copper is known to exist in three separate localities, though in one case the information is based solely on reports by Esquimos. The Coppermine district, on Coppermine river, which flows into Coronation gulf, has already been described by Sandberg and by Douglas, as recounted in our issue of January 1915. The district known only to Esquimos is in the region of Prince Albert Sound, on the island known as Victorialand. The third district is in and about Bathurst Inlet, east of the Coppermine district. It was investigated by the Canadian Arctic Expedition in 1915-16, the report of which has not been published. As Mr. O'Neill's notes show that the deposits here are of unusual interest we quote this part of his paper.

The copper-bearing rocks in Bathurst Inlet occupy a pear-shape area extending about 50 miles northwest-southeast by about 25 miles at the greatest breadth. This area includes more than 200 islands ranging in size from a few hundred square yards to several square miles, and also part of the western mainland, Banks peninsula, and a strip of coast from Arctic Sound to Moore Bay and 5 or 6 miles inland. The islands and Banks peninsula have been mapped and investigated, but the copper content of the remainder of the mainland has not been established, although the same rocks are known to occur there. The formation is a series of basic lava flows with three thin beds of sediment. The total thickness is over 400 ft. on Banks peninsula, and native copper was actually seen in rocks representing over 350 ft. of this thickness. Similar rocks are found throughout the area where exposed on the islands. The general dip is about 6° and makes a shallow basin of the area.

The copper occurs native in three forms: (1) vein-copper, in thin fissures in the rocks; (2) amygdaloidal copper, irregular grains and small masses in the branching gas cavities near the surface of the flows; (3) disseminated copper, minute flakes scattered throughout the ground-mass. Nos. 1 and 2 are locally important but No. 3 is the most widespread. Vein copper occurs as thin sheets of native copper, and as small flakes and pieces scattered through a matrix of quartz, calcite, etc. A sample of the latter, from a one-half-inch vein, ran 4·56% copper. In parts of the area this vein copper is important in amount, but no attempt was made to estimate its relative importance. Amygdaloidal copper is found in the upper portion of the flows where the gas cavities were numerous and a free passage was permitted to the mineralizing solutions. Only occasionally was this type visible for examination because of accumulations of talus or of snow along the cliff-face. A sample from one of the exposures gave 1·44% copper. No estimate was made of the amount of this material available. Disseminated copper occurs over the whole area of more than 1,000 square miles and practically through the whole thickness of the formation. Analyses of forty-five representative samples show that the values range between 1/100 and ¼%. This copper is in tiny flakes and can usually be seen with a lens.

A rough estimate of the amount of rock carrying values in native copper, neglecting those parts on the mainland where the copper content was not established, is as follows: Banks peninsula more than 10 square miles; Islands more than 50 square miles. Based on a minimum thickness the tonnage available would be 6,000,000,000 tons. It will, however, require considerable detailed sampling to determine whether the total percentage of copper is sufficiently large to pay for working the deposits wholly or in part. When it is considered that copper values are found over the whole area of more than 1,000 square miles, it seems highly possible that there is sufficient concentration in parts of this area to permit of economical mining.

In many parts of the southern half of the area of copper-bearing rock in Bathurst Inlet a series of dolomites immediately underlies the basalts; the upper few feet of this series is partly replaced by bornite in layers and masses. Exposures occur in cliffs facing the east and southeast at various places, and further investigation should be made.

Petroleum in Assam.—At the meeting of the Institution of Petroleum Technologists held on April 17, H. S. Maclean Jack read a paper on the "Development of the Petroleum Industry in Assam." Assam is a small State in India, lying to the north-west of Burma, and adjoining the eastern end of the Himalayas. The Brahmaputra river passes through it in a south-westerly direction, forming the great Assam Valley. The existence of petroleum has been known since 1828, when traces were found by a party of engineers exploring for coal. Several concessions were granted in the 50's and 60's. In 1881 the Assam Railways & Trading Co. was formed to build a railway, work coal mines, etc., and among other things, the company secured an oil concession on the Makum Pani river, a tributary of the Dehing river. This concession had been drilled for oil in 1865. The company's engineers subsequently found a better petroleum show at Digboi, 10 miles to the north, and the first well was drilled on it in 1893. In 1899 the company formed a subsidiary, the Assam Oil Co., to take over the Makum and Digboi concessions. From this time the petroleum history of Assam has been the history of the Assam Oil Co. The author proceeds to give an account of the geological investigations, made by Sir Thomas Holland, and of the campaign of well-drilling. He also describes the oil produced, and the methods of manufacture of the various products.

The Belgian Congo.—At a meeting of the Royal Society of Arts held on March 6, Dr. M. Horn, of Brussels, read a paper on the "Economic Development of the Belgian Congo." The author reviewed the history of the State and described its government. He gave particulars of the physical geography and ethnology, and of the resources of the country as regards minerals, agriculture, etc., and of the methods adopted for establishing communications. As regards minerals, the copper deposits of Katanga are well known, and more of the tin deposits in the same region will be known later. The diamond production on the Upper Kasai is assuming important proportions under the direction of the Société Internationale Forestiere et Miniere, a Belgian-American company. Alluvial gold is worked at Kilo and Moto in the north-east district of Ituri. There are coal seams at Lukuga near Lake Tanganyika, and iron ore deposits in the district of Uele and Ituri. Kaolin is found in the coastal district.

In the partition of Africa into spheres of European influence, the Belgian claims to any extensive seaboard had to take second place to those of France and Portugal, with the consequence that the approach from the sea is confined within narrow limits, the seaboard comprising little more than the mouth of the river Congo. Thus there is only one seaport, Banana. From 50 to 100 miles up the river, other ports have been or are being established, at Matadi, Boma, and Ango-Ango. From Boma to Stanley Pool, the latter 300 miles from Banana, the rapids interfere with navigation, and indeed from Matadi to Stanley Pool water communication is impossible. In the upper reaches of the Congo and its tributaries, the depth of the water is not great, and the steamers do not as a rule draw more than 3 ft. To connect the upper Congo with the ocean, a railway was commenced in 1893 between Matadi and Leopoldville. This line is 250 miles long, but is of narrow gauge, only 2 ft. 4 in. wide. This was completed in 1899. The next lines to be undertaken were in the eastern province, having for their object the linking of two navigable parts of the upper Congo separated by Stanley Falls and several rapids. One section is between Stanleyville and Ponthierville, 83 miles, and the other between Kindu and Kongola, 222 miles. The highest point to which steamers have access is Bukama, 2,200 miles from the mouth. The railway connecting Bukama with the Katanga railway system is nearly completed. The Katanga railway enterprise, under the control of Mr. Robert Williams, was described in an editorial article last month. This railway connects the Katanga copper belt with Bulawayo and Cape Town. The plans for connecting the Congo State with the Indian Ocean were undertaken contemporaneously with the German railway developments in German East Africa. The German railway connects Ujiji, on lake Tanganyika, with the coast at Dar-es-Salaam. The Belgian railway commences at Kalemie on the opposite side of Tanganyika, a little to the south of Albertville, and connects with the Congo at Kabalo. This railway was completed toward the end of 1915. It is intended at a later date to connect Kabalo and Kongola. The only other railway in existence at present is a short line north of Boma serving

cocoa plantations. Plans for a railway connecting Congo State with the Sudan and Egypt have not yet materialized, and appear to be indefinitely postponed. In the meantime railway construction to develop the north-east section of the State and also the Kasai districts in the south-west is contemplated. One possible route to the north-east would be from Bumba or Basoka, on the Congo, through Buta to the Mota goldfield and Aba. Another would be east from Stanleyville to Albert Nyanza and the Kilo goldfield. The Kasai district is to be connected with the Katanga railway on the east and Leopoldville on the west, by a line passing through the towns of Leverville and Luebo, and this line will be connected also with Lusambo and Kabalo. Eventually a French railway will have its terminus at Stanley Pool, and a Portuguese railway from St. Paul de Loanda will enter the Kasai district.

Cementation Process in Mining.—Last month a paper was presented by Thomas Blandford to the Midland Institute of Mining, Civil, & Mechanical Engineers on the cementing process as applied to mining, reference being made particularly to the stoppage of water flows by means of injected cement by the Francois system. This method was first applied for shaft-sinking through wet strata in Northern France and Belgium about 10 years ago. Since then it has been used in the North of England, South Wales, and Kent. The present paper gives an outline of what has been and can be done by this method, and the author promises further papers giving details of a number of particular cases. We note herewith two of his points. In the first place he compares the relative advantages of two methods of applying the process to sinking: (1) bore-holes through which the cement is introduced into the ground may be put down inside the perimeter of the shaft required to be sunk, and (2) bore-holes may be put down around the outside of the perimeter of the shaft in a similar way to the bore-holes used in the freezing process. The first of these two methods has the advantage of indicating clearly the position of all water-bearing fissures, and also gives an approximate idea of the size and extent of such fissures, as both the quantity of water and its pressure are registered as soon as any fissures are encountered. The cementation in this case is carried out in successive stages, that is to say, a predetermined depth of ground is first of all treated, sunk through, and then lined; after this work has been completed, an entirely fresh set of bore-holes is put down from the shaft-bottom and inside the perimeter of the shaft. On reaching a fissure containing water during boring, this water rises up the bore-hole pipe; but as a stop-valve is fitted on the pipe, the water is kept under absolute control until it is dealt with by cementation. The second method, in which the holes are bored outside the perimeter of the shaft, is said to have the advantage that cementation and sinking can be carried out simultaneously. This method, under certain conditions, may be attended with satisfactory results; but, in the author's opinion, where such bore-holes are put down from the surface to intersect a variety of fissures, both large and small, and the injection of the cement is carried out continually from the surface level of the shaft and above the normal water-level of the ground, there is less likelihood of obtaining successful results than when the cement is introduced from the shaft. There is always a tendency for the cement mixture to follow the line of least resistance during injection in such a way that if the bore-hole intersects a large fissure attended with several smaller ones, the most extensive fissure would be filled with cement, whereas the smaller fissures may only be filled in the immediate vicinity of the bore-hole; and upon proceeding subsequently with the sinking, water would be found still to exist in the region of the small fissures in the ground as a result of imperfect injection.

The second point in the author's paper refers to cases where the flow is unusually heavy. In sinking at Hatfield Main in Yorkshire, it was found impossible to introduce cement into the ground to any useful purpose, as it was washed out by the pressure of water. Instead, however, of discarding the process altogether, the work was persevered with until finally all difficulties were overcome by the introduction of a chemical process of precipitation which facilitated the introduction of the cement into the ground. Two chemical solutions were employed, the properties of which produced, when mixed, the formation of a gelatinous precipitate which, by sealing the pores of the sandstones in the walls of the fissures and the loose material in the fissures, permitted of the introduction of the cement. The chemicals used in this instance were silicate of soda and sulphate of alumina, and the most efficient precipitation effect was obtained, by experience, in the degree of concentration of the respective solutions. The author does not enter closely into the details of this work, as it will form the subject for another paper to be published at a later date.

Stope Measurement at the Messina Mine.—At the meeting of the Institution of Mining and Metallurgy held on April 19, a paper by William Whyte was presented describing the method of measuring stopes at the Messina copper mine, in the northern Transvaal. The orebodies are nearly vertical and very irregular in cross-section. Stoping is done by slicing and filling at some places, and by shrinkage at others. The ore is too soft to stand without support, and timbers are extensively used. The first slice of any stope is horizontal, but the back often becomes inclined as stoping proceeds, and may vary considerably in elevation. It was sought to obtain accurate horizontal cross-sections of the shoots at regular intervals. Owing to interference of these timbers and to the small vertical space in the stopes, it was impossible to use the theodolite for surveying these contours. There were also the difficulties incidental to connecting stope surveys with development surveys through long narrow passes, and the necessity of employing kaffir assistants who could not be trusted to work reliably at more than 20 ft. from the observer. In the method finally adopted the hanging compass and clinometer were used for the necessary traverses and the polar protractor for details. We give herewith a short description of the field work, but we have not space for an account of the office work or for a discussion of the limits of application and the accuracy of the method. Nor have we space to reproduce the illustrations.

Copper nails with numbered tickets are driven into the timbers at the bottom of the manways of the cribbed passes, generally at a corner. The nails are connected to the survey of the level and their elevations determined. In the stope, any convenient pass is taken as a starting-point for the survey. A numbered copper nail is driven into the timbers in the same relative position as the nail below, and the distance between the nails measured. The passes can usually be treated as truly vertical without material error, but, if necessary, any deflection is easily determined by the use of a plumb-line or clinometer for inclination, and the compass for direction. From this upper nail, stout twine, 100 ft. or more in length, is ranged round the stope, as a closed traverse, or to the reference nail in the next convenient pass. Supports for the string are provided by means of ordinary nails driven into the timbers, wedges driven into cracks in the rock, or long pegs driven into the day's drill-holes. Supports are considered stations, and the lines are deflected as much as necessary to give the most effective positions. Between stations the lines are drawn taut, and care is taken that they foul nothing. The stations may be as close together as necessary, but should not be more than 25 ft. or 30 ft. apart, in order to avoid excessive sag, and to keep the effect of any error made in reading, whether due to carelessness or local attraction, at a minimum.

The compass is hung on the line at a convenient point, with the whole-circle zero forward in the direction of the traverse. The north-seeking end of the needle is read as a continuous bearing to a $\frac{1}{4}°$, when all steel, such as hammers, drills, shovels, picks, etc., has been removed to fully 20 ft. from the instrument. Steel-buckled belts are avoided, but it is found that the nails in mine boots cause no apparent deflection if the feet are kept vertically below the compass, or in line with the needle. After removing the compass, the clinometer is hung at each end of the line in turn, about 18 in. from the supports, and both readings of inclination noted. There is a difference between the readings due to sag, varying with the tension of the string and the distance between stations.

Local cross-sections of the stope are then taken by means of the polar protractor. This instrument, though simple, is little used by mine surveyors, and the modified form adopted warrants description: A circular piece of 16 S.W.G. sheet brass, 8 in. diam., is marked on one side at every 5° from 0° to 360° in cyclic order. The first and fourth quadrants have the central portions removed, and from 180° to the centre a slit is cut which is just equal in width to the diameter of the string used. The protractor is placed in position by passing the slit over the string, when it will hang in a vertical plane which is at right angles to the vertical plane of the traverse line, and the zero of the protractor will be vertically over the string at its centre. Any tendency of the protractor to slide along steep lines is easily counteracted by the compass clips.

The cross-sections are taken at every significant change in the shape of the stope. The protractor is hung on the line so that the graduations face the observer, who looks in the direction of the traverse. The ring of a linen tape is fastened by a spring hook to the end of a light extensible rod, and by means of the rod an assistant holds it, in turn, on the salient points in the cross-section desired. The tape is drawn taut and held in front of the protractor, just touching the string. The observer then reads the inclination and length of the offset, keeping the tape in the correct plane by noting that it is parallel to the protractor. The offsets are limited in length on account of (1) sag, (2) difficulty of adhering to cross-section plane, and (3) magnification of errors due to reading incorrect inclinations; and they should not ordinarily exceed 12 ft. The distances of the cross-sections along the traverse line are noted, and for this purpose it is convenient to lay previously a special draft tape along the line, with its end fastened to the point of commencement.

Platinum in South Spain.—At the meeting of the Institution of Mining and Metallurgy held on April 19, a paper by F. Gillman was presented, describing an occurrence of platinum in the Ronda highlands, province of Malaga, south Spain. This occurrence was discussed in our issue of December last, page 363.

Gold Melting.—At the spring meeting of the Institute of Metals, W. J. Hocking described the plant at the Royal Mint for melting gold. Gas is the fuel employed, and the Brayshaw burner is used.

Tin Assays.—Records of the Geological Survey of New South Wales, Vol. 9, part 3, contains a paper by J. C. H. Mingaye detailing his researches in connection with the application of various methods of tin assay to the New South Wales tin ores.

Zirconia.—In our issue of January 1915, we gave particulars relating to the use of zirconia as a refractory material. This subject was treated in full detail by J. A. Audley at a meeting of the English Ceramic Society held in March.

Sulphur Dioxide in Flotation.—The *Mining and Scientific Press* for April 7 describes the use, at the Broken Hill Proprietary, of sulphur dioxide as flotative agent.

RECENT PATENTS

11,820 of 1915. E. DE ST. LAURENT and R. B. MACKINTOSH, London. Splitting the silicate of alumina contained in common clay by mixing the latter with acidulated distilled water, and treating the resultant mass with superheated steam at a comparatively high temperature. The hydrate of alumina thus formed is soluble in water and can be separated.

13,168 of 1915. H. A. LEAVER AND H. H. HOSACK, London. In recovering tin from scrap tinplate, a method of passing through an electrolytic bath containing hydrochloric acid.

14,055 of 1915. A. CLASSEN, Aachen, Germany. Producing ammonia by catalytic contact of nitrogen and hydrogen and the simultaneous action of dark and spark electric discharges.

86 of 1916 (104,516). F. H. HAVILAND, London. In smelting zinc-lead sulphides, the production of free sulphur by the action of a reducing gas mixed with the right amount of oxygen, and subsequently reducing the zinc oxide in the same furnace and precipitating the zinc fume thus produced by electrostatic means.

1,063 of 1916 (104,697). H. L. SULMAN, H. F. K. PICARD and the METALS EXTRACTION CORPORATION, London. In preparing the solution obtained by leaching roasted zinc ores with acid, neutralizing the solutions by the addition of zinc hydrate before sending them to the electrolytic depositing baths.

2,902 of 1916 (104,366). MINERALS SEPARATION & DE BAVAY'S CO., Melbourne. Methods of regulating the levels in the series of cells of a flotation plant.

2,903 of 1916 (104,367). F. J. LYSTER, Broken Hill. A modification in flotation apparatus described in patent 10,666 of 1915.

3,878 of 1916 (104,734). E. WURST, Saarbrucken, Germany. Method of producing nitric oxide in internal combustion engines, to be used in the manufacture of nitric acid.

4,311 of 1916 (104,564). D. B. JONES, Chicago. Method of distillation of zinc ores in briquette form, the carbon incorporated therein being coke.

10,450 of 1916 (101,091). SOCIETE GENERALE DES NITRURES, Paris. Improvements in the process for producing aluminium nitride by acting on aluminium compounds with nitrogen.

10,408 of 1916 (101,030). T. A. MITCHELL, Reading, Mass, U.S.A. Method of making lead and other arsenates.

17,145 of 1915. H. J. JACK and A. G. LOBLEY, London. Producing aluminium powder by blowing a jet of compressed air on a stream of the molten metal.

NEW BOOKS

Engineering Analysis of a Mining Share. By J. C. Pickering. Cloth, octavo, 92 pages; price 6s. 3d. New York: McGraw-Hill Book Co.

The author is a well known American appraiser of mines. English readers will remember his work in connection with the Falcon gold-copper mine in Rhodesia. He has also had extensive experience in Mexico and South America. His wider acquaintance with conditions outside the United States gives him an advantage over Mr. J. R. Finlay, the author of "The Cost of Mining," especially in connection with labour problems. We are not sure that the title of Mr. Pickering's book is quite suitable; probably some broader title embodying the idea of the commercial side of mining from the capitalist's point of view would express his aim and scope better. His comments on methods of financing and development of mines are interesting reading, as is also his review of the various items that have to be considered in preparing a mining report. He has much to say relating to the difference between working profits and dividends, and of the choice of methods which will secure the greatest profit. While not containing any novel idea or proffering any new thesis, the book is worth reading by engineers and mining directors for the author's obiter dicta. Unfortunately the book is occasionally marred by careless statements. For instance, it is said that on the Rand "amalgamation is to some extent employed." In the list of Rand controlling houses, no mention is made of Johannesburg Consolidated, an omission that will not do nowadays. Then West Africa is included in Central Africa, and the general statement is made that the Central African climate is enervating and unhealthy. This is not fair to the central plateau.

Russian Verbs made Easy. A guide to the use of Russian verbs, intended for the use of business men and others. Arranged and compiled by Stephen J. Lett, M.Inst.M.M. Cloth, octavo, 60 pages; price 2s. 6d. London: Kegan Paul, Trench, Trubner & Co.

In view of the generally prevalent opinion that the Russian language is exceptionally difficult, Mr. Lett has performed a very useful service in placing at the disposal of business men a simple and practical guide to Russian verbs, for it is in the Russian verbs that the real difficulties of the Russian language lie. Russian has suffered like all modern European languages from too much Latin grammar. The Latin grammar, as we know, was invented by the Greeks. Before their advent the Romans had no grammar of their own. The Greeks constructed a Latin grammar in the light of their own, and as Latin became the universal language of scholars, the grammars of most modern languages have taken the Latin grammar for their model. Thus the first Russian grammar which was written by that inspired peasant Lomonossoff was an attempt to stretch upon the Procrustean bed of the Latin language the strong and flexible young vernacular of Russia. Since then there have been many improvements and changes by Russian grammarians, but as in the case of German and English it may be stated with some degree of truth that the rules of the Russian grammar are riddled with exceptions.

Mr. Lett has written a short but an extremely practical explanation of the aspects of the verbs, and he has in our opinion contributed largely to the reduction of their terrors. What he says about prepositional prefixes is also extremely practical and put in a very brief and condensed form. Mr. Lett might have pointed out that in the matter of prepositional prefixes the Russian verb bears some resemblance to the German, and is thus totally different from the English. It is extremely useful to have before one a short list of the prepositions usually prefixed to the Russian verbs and their meanings. This will facilitate enormously the English business man who in looking up the meaning of a verb in a dictionary will often be annoyed by his failure to find it. By cutting off the prepositions, the meaning of which is given in this little handbook, the student will have no difficulty in finding the root of the word in the dictionary, and as he has been told what the preposition means the interpretation of the meaning of the verb will be facilitated. Generally speaking, Mr. Lett has succeeded in simplifying to the English reader the difficulties of the Russian verb, difficulties which do not present themselves to the Russian mind, seeing that the Russian has been trained by common parlance from early youth in the use of this flexible method of expression.

Russian is after all a new language, more modern even than German, though not so modern as French, but it is based upon the ancient and archaic Slavonic, much as English is based on Anglo-Saxon. We in this country have been obliged to import from other languages expressions to convey the ideas for which the old original language had no words. In German this has been avoided as much as possible by the use of prepositions, and by the introduction of composite words. To some extent this practice has been copied in Russia, but the Russian language, like our own, has in many cases bodily incorporated foreign words. This remark does not, however, apply to the verbs, which are purely Russian and express in a unique manner all the vigour, the simplicity, and the directness of the Russian mind.

We feel certain that Mr. Lett's book will be found of very great assistance and value not only to business men but to all students of the Russian language.

E. A. Brayley Hodgetts.

Bibliography of Flotation. Technical Paper 135, published by The United States Bureau of Mines. By D. A. Lyon, O. C. Ralston, F. B. Laney, and R. S. Lewis. This pamphlet contains references to articles and patents relating to flotation published during the first half of 1916.

Sulphuric Acid and Alkali. Supplement to Vol. 1. By George Lunge. Cloth, octavo, 360 pages, illustrated; price 15s. net. London: Gurney & Jackson.

This book is a supplement to Vol. 1, of Professor Lunge's series of volumes, and deals with recent developments in the manufacture of sulphuric and nitric acids.

Oil and Petroleum Manual for 1917. By Walter R. Skinner. Cloth, octavo, 230 pages; price 2s. 6d.net. London: W. R. Skinner.

This is the eighth yearly issue of a volume containing information relating to the oil and petroleum companies registered or known in London. The scope and arrangement of the book are on similar lines to those of the well known Mining Manual. We are glad to find that Mr. Skinner is a believer in the conservation of gold, for the usual gold leaf on the cover is replaced by black lettering.

Melting Aluminium Chips. Bulletin 180 of the United States Bureau of Mines. By H. W. Gillett and G. M. James. This pamphlet contains much valuable information relating to the melting of aluminium scrap and the uses and characteristics of the metal produced by melting.

COMPANY REPORTS

Tharsis Sulphur & Copper.—This company has its headquarters in Glasgow, and operates the Tharsis and Calanas pyrite mines in the south of Spain. The firm of Charles Tennant, Sons, & Co., the chemical manufacturers, are largely interested in it, and Lord Glenconner, head of that firm, is the chairman. As the bulk of the output is shipped to this country, the company did not suffer so greatly as some others in the south of Spain on the outbreak of war. Profits have risen during the past two years, and the dividends were 15% for 1916, as compared with 12½% for 1915, and 10% for 1914. The report for 1916 shows that 14,211 tons of ore was extracted from the Tharsis mine and 389,197 tons from the Calanas mine; in addition, 12,676 tons of cupreous sterile was extracted at Calanas for treatment on the mine. These figures are much the same as those of the year before. The shipments of ore, including washed ore, from the port of Huelva were 574,078 tons, and of copper precipitate 1,377 tons. At the copper smelting works in Great Britain, improved furnaces have recently been erected, and the amount of ore treated in this way will be increased. Little washing is now being done at the mines. The total copper output for 1916 was 3,712 tons. The accounts show a net profit of £199,149, and £187,500 has been distributed as dividend.

Mason & Barry.—This company was formed privately in 1858 to work the San Domingos sulphur and copper mine at Mertola, Portugal, just over the border of Spain, and on the same mineral belt as the Rio Tinto and Tharsis. The company was expanded in 1878, and public subscriptions were then invited. In 1892 the company was reconstructed and the capital reduced by one-half, with a return of capital of £1 per £10 share. Since then the £5 share has been further reduced to £1 by successive returns of capital. The nominal capital has since 1900 stood at £210,000 in £1 shares. The report for the year 1916 shows that 193,127 tons of ore was raised, and that the shipments, including ore from the cementation works, was 202,176 tons. The net profit for the year was £99,166, out of which £83,327 has been distributed as dividend, being at the rate of 45%. The rate for 1915 was 30%, and for 1914 15%. Since the reconstruction in 1892 the dividends have totalled £1,453,592, and the return of capital in cash £740,688.

Barramia Mining & Exploration.—This company was formed in 1909 by John Taylor & Sons, as a subsidiary of the Egypt & Sudan Mining Syndicate, to acquire the Barrahme gold mine, situated between Edfu, near Assouan, on the Nile, and the Red Sea. The mine contains lodes that are enriched at places by pockets, and these pockets have provided the profits. The report for the year 1916 shows that the chance of finding any more pockets is remote, and that the average content of the remaining ore is low. During the year, 6,520 tons of ore yielded gold worth £12,376, as compared with 5,870 tons and £15,230 the year before. The decrease in the yield caused a loss of £2,586 on the year's work. It has been decided to stop the development, and to extract such of the remaining ore as can be mined at a profit. Arrangements are also being made to treat the accumulation of 20,000 tons of sand and slime by the cyanide process, and money has been privately borrowed wherewith to erect a cyanide plant. The mine contains a large amount of pyritic ore that was not amenable to amalgamation, but can be treated by cyanide. The company also owned the Semna mine; this has been sold to the Atallah Company for £2,500 in shares.

Broken Hill Proprietary.—The half-yearly report now issued covers the period ended September 30 last. During this time, operations at Broken Hill were fairly continuous, two short suspensions due to labour disputes causing a loss of only one week. The output of lead-zinc-silver ore was 110,276 tons, as compared with 66,423 tons during the previous half-year, the latter having been greatly upset by the strike for shorter hours. At the lead mill, 97,630 tons of ore was treated for a yield of 17,065 tons of lead concentrate, averaging 58·73% lead and 28·12 oz. silver per ton. The flotation treatment of zinc tailing was resumed toward the close of the period, and 13,232 tons was passed through the plant, yielding 2,805 tons of zinc concentrate averaging 47·4% zinc, 5·72% lead, and 13 oz. silver. The Bradford slime plant was started in September. The capacity of the plant is 3,000 tons per week. The lead concentrate averages 56% lead and 80 oz. silver, and the zinc concentrate averages 46% zinc; most of the silver goes into the lead concentrate. Exploration by diamond drill has made no addition to the ore reserves. At the iron and steel works at Newcastle, the output was 29,332 tons of rails and other finished products. We have already given particulars, in our February issue, of the plans for extending the iron and steel plant. The accounts show a working profit of £191,007, out of which £43,366 was allocated to income tax, £16,404 to debenture interest, and £15,000 to debenture redemption, while £118,100 was distributed as dividend, being at the rate of 25%. During the current half-year no dividend has yet been paid, the directors considering it advisable to pass the usual distribution in February owing to the unsettled labour conditions.

Broken Hill South Silver.—The report for the half-year ended December 31 shows that 157,059 tons of ore was raised and treated, averaging 14% lead, 13·8% zinc, and 6·7 oz. silver per ton. The half-yearly outputs have been irregular lately owing to a strike and to difficulties of disposal of products due to the war. The present figure compares with 172,431 tons during the half-year preceding the outbreak of war. At the lead mill 27,650 tons of lead concentrate was produced, averaging 60·6% lead, 8·9% zinc, and 21·3 oz. silver per ton, together with 86,737 tons of zinc tailing averaging 16·6% zinc, 3·2% lead, and 3·1 oz. silver, and 25,414 tons of slime averaging 9% lead, 14·5% zinc, and 7 oz. silver. The tailing rejected amounted to 17,659 tons averaging 6·4% zinc, 1% lead, and 1·2 oz. silver. The plant for treating the slime by selective flotation was working throughout the half-year as far as the production of a lead concentrate was concerned. The amount treated was 13,642 tons averaging 10% lead, 13% zinc, and 7·1 oz. silver. The lead concentrate produced was 1,924 tons averaging 58·7% lead, 9·3% zinc, and 44·7 oz. silver, leaving 11,718 tons of zinc tailing averaging 13·6% zinc, 2% lead, and 0·9 oz. silver. The first unit of the zinc section of the selective flotation plant is completed, and experimental work is in hand to determine the most suitable method of extracting a high-grade zinc concentrate. The Amalgamated Zinc (De Bavay's) Company took delivery of all the current zinc tailing exclusive of slime tailing, and there was delivered to the Zinc Corporation 20,008 tons of tailing from the old dumps averaging 16·9% zinc, 5·6% lead, and 4·1 oz. silver. The working cost per ton, including mining, concentrating, and development, was 24s. 1d. The working profit was £255,789, out of which £20,000 was placed to income-tax account, £5,968 was paid as debenture interest, and £120,000 was distributed as dividend, being 12s. per £1 share. The sum of £105,292 was carried forward. As recorded a year ago, the lowest level, at 1,270 ft. did not give good results at first. Diamond drilling was undertaken, and ore, as recorded in the previous half-yearly report, has been found. The present report gives details of eight bore-holes, all showing ore equal in value to that in the upper levels. The reserve of proved ore, not including ore disclosed by drilling, is estimated at 3,500,000 tons.

North Broken Hill.—The report for the half-year ended December 31 last shows that labour conditions were more nearly normal. Only 3½ weeks were lost, most of this being accounted for by the Christmas holidays. During the period, 117,190 tons of lead-zinc-silver ore was treated, averaging 15·2% lead, 12·6% zinc, and 7·1 oz. silver per ton. The lead concentrate extracted was 23,123 tons averaging 60·6% lead, 8·6% zinc, and 20·6 oz. silver. In addition there was produced 56,542 tons of zinc tailing averaging 15·6% zinc, 3% lead, and 3·2 oz. silver; 18,365 tons of slime averaging 9% lead, 14·5% zinc, and 7 oz. silver; and 19,160 tons of rejected tailing averaging 2·4% lead, 7% zinc, and 2·2 oz. silver. The zinc tailing was delivered to the Amalgamated Zinc (De Bavay's) company. The working cost, including mining, milling, and development, was 21s. 10d. per ton, as compared with 18s. 2d. during the second half of 1915. The development continued to expose ore of average grade, and the reserve is estimated at 2,850,000 tons. The accounts show an income of £329,337 from the sale of concentrate and tailing, and a net profit of £164,203. Out of this, £120,000 has been paid as dividend, being 20% for the half-year.

Ooregum Gold.—This company operates one of the gold mines belonging to John Taylor & Sons' group in the Kolar district, Mysore State, India, the mine being between the Nundydroog and Champion Reef. Mining commenced in 1888, and dividends have been paid continuously since 1891. The report for the year 1916 shows that 155,317 tons of ore was milled, yielding 75,988 oz. gold, and that 222,355 tons was treated by cyanide yielding 14,632 oz., being a total of 90,621 oz., realizing £384,302. The working cost was £200,940, royalty £21,992, allowance for depreciation £26,000, income tax £10,931, placed to reserve £5,000, and dividends £120,231, being 40% on the preference shares and 30% on the ordinary shares. Development during the year added 53,196 tons to the reserve, which now stands at 420,821 tons. As recorded in our last issue, the lowest level, No. 52, in Bullen's section has been in broken ground. We also mentioned that improvements in the mill had increased the percentage of recovery.

Balaghat Gold.—This company operates the most northerly of the series of properties in the Kolar goldfield, Mysore State, belonging to the John Taylor & Sons' group, and it has been the least successful. Its early fortunes were unfavourable, but from 1900 to 1907 good dividends were paid. Since then it has only been possible to meet expenditure, and the developments have only been on a small scale. The report for 1915 shows that 28,476 tons of ore yielded 16,033 oz. of bullion, and that 57,438 tons of tailing yielded 3,690 oz. The value of the total bullion produced was £75,176. The tonnage treated was less by 6,000 tons as compared with 1915, but as the grade was much higher, the total yield was £7,000 more. The year's work resulted in a loss of £7,185. The Balaghat lode is to be further investigated at depth. In the meantime the Main lode, where the workings are much shallower, has given small blocks of high-grade ore between the 1,050 and 1,450 ft. levels. The ore reserve on December 31 was estimated at 29,648 tons.

Ivanhoe Gold Corporation.—This company was floated in 1897 by Whitaker Wright to acquire a gold mine at Kalgoorlie from a Melbourne company of similar name, which had done well for its shareholders during the previous two years. Since 1903, Bewick, Moreing & Co. have been the consulting engineers. Handsome dividends have been paid regularly, though during the last three years the rate has been diminished. Below the 2,420 ft. level little ore has been discovered, though the main shaft has been sunk to 3,620 ft. and an extensive campaign of diamond-drilling undertaken. Attention has been turned recently to further exploration of the upper levels, and the ore reserve has been maintained thereby. The report for the year 1916 shows that 240,050 tons of ore was raised and gold worth £381,647 extracted, the yield per ton being 31s. 9d. The profit was £119,279, out of which £12,000 was allocated to income tax, and £105,000 distributed as dividend, being at the rate of 10½%. The ore reserve is calculated at 1,002,096 tons, averaging 36s. 3d., as compared with 1,026,801 tons averaging 36s. 10d. the year before.

Brakpan.—This company was formed in 1903 to develop a deep-level gold-mining property in the Far East Rand. It belongs to the Transvaal Coal Trust (now Rand Selection Corporation) and Consolidated Mines Selection group. Milling started in 1911, and the first dividend was for the year 1912. The report for 1916 shows that 808,619 tons of ore was raised, and that after the removal of 12½% waste, 709,300 tons averaging 7·68 dwt. per ton was treated at the stamps. The yield by amalgamation was 163,497 oz. and by cyanide 97,436 oz., making a total of 260,933 oz., worth £1,097,761, or 30s. 11d. per ton. The working cost was £684,535, or 19s. 3d. per ton, leaving a working profit of £413,226, or 11s. 8d. per ton. It is notable that the grade of the ore milled was 3s. higher than the year before, the working cost 1s. 3d. higher, and the total working profit £55,887 higher. The shareholders received £339,750, being at the rate of 45%, as compared with 40% for 1915, and 32½% for 1914. In addition £100,000 was allocated to capital expenditure on the new area leased, details of which were published recently. During the year, 20,978 ft. of development was done. The reserve is estimated at 3,054,000 tons, a figure virtually the same as that for a year ago; but the assay-value is much higher, being 9·2 dwt. as compared with 7·86 dwt.

New Kleinfontein.—This company belongs to the Anglo-French Exploration group. It was formed in 1893 to acquire an outcrop property in the Far East Rand to the south-west of the Van Ryn. In 1914 the Benoni and Apex properties were absorbed, and a new metallurgical plant was erected on the Apex, milling starting in July of last year. The report for 1915 shows that 866,518 tons of ore was raised in the two sections, and 18% of waste sorted out. The separate amounts raised from each section are not given, but it is stated that 614,200 tons was treated at the New Kleinfontein plant and 116,620 tons at the Apex plant. At the Apex plant 45 stamps were at work, crushing to 8-mesh with a duty of 15 tons per day per stamp, as compared with 8·9 tons at the Kleinfontein. The extractions and costs at the two plants are reported together. The average content of the ore milled was 6·2 dwt. The yield by amalgamation was 140,415 oz. and by cyanide 74,682 oz., making a total of 215,107 oz., worth £913,472, or 25s. per ton. The working cost was £689,162, or 18s. 10d., leaving a working profit of £202,938, or 5s. 6d. per ton. Out of the profit, £27,893 was paid as taxes, £12,017 as interest on loan, and £109,000 allocated to capital expenditure on development and plant, while £57,577 was distributed as dividend, being at the rate of 5%. The estimate of ore reserves is as follows: 1,726,861 tons in Kleinfontein averaging 5·6 dwt., 659,578 tons in Benoni averaging 4·73 dwt., and 557,555 tons in Apex averaging 5·41 dwt.

Lahat Mines.—This company was formed in 1906 for the purpose of acquiring a tin-gravel property at Lahat, in the Kinta Valley, Perak, Federated Malay States, and it belongs to the same group as the Tronoh. Excellent results were obtained during the first years, but owing to exhaustion of the richer parts, the output and profits seriously diminished in 1914 and 1915. Two years ago Osborne & Chappel were appointed general managers. The report now published covers the year 1916. During this period, ground of higher content was treated. The yardage was 242,461 as compared with 298,444 in 1915, but the piculs won amounted to 7,357 as compared with 4,431. The concentrate sold was 438 tons as compared with 264, and the income £47,558 as compared with £25,522. The profit was £17,339, after due provision for the depreciation of plant. The directors have written £2,877 off property account, and have transferred £5,000 to reserve. A dividend of £6,000, at the rate of 5%, has been paid.

Plymouth Consolidated Gold Mines.—This company was formed in 1914 by Bewick, Moreing & Co. to acquire a gold mine in Amador county, California, that had been re-opened on the recommendation of W. J. Loring, one of the partners. Milling commenced in August 1914, and dividends were earned in 1915. The report for the year 1916 shows that 125,000 tons of ore was raised and milled, yielding 24,565 oz. of gold by amalgamation, and 8,127 oz. in concentrate. The tailing averaged rather over ½ dwt. The yield was worth £140,154, equal to 22s. 5d. per ton. The net profit was £45,361, out of which £36,000 was distributed as dividend, being at the rate of 15%. Development work has been centred on the new ore-shoot discovered over a year ago on the 1,400 and 1,200 ft. levels. Both on these levels and on the 1,065 and 950 ft. levels this ore-shoot has given a good account of itself, and a large amount of ore has been disclosed. A small amount of development was also done at depth, on the 2,450 ft level. In order to provide a second exit from the mine, the Indiana shaft has been sunk and communication has already been made with the workings in a rise from the 950 ft. level.

Nipissing Mines.—This company is a New York corporation owning the shares of the Nipissing Mining Co., a Canadian company, which operates one of the first developed silver-mining properties at Cobalt, Ontario. The ore is treated by the cyanidation-amalgamation method, which has several times been decribed in our columns. The report for 1916 shows that 1,269 tons of high-grade ore and 76,851 tons of low-grade ore were raised. The high-grade plant treated 1,064 tons of ore and metallics averaging 1,800 oz. silver per ton, and the low-grade plant treated 76,957 tons averaging 32 oz. per ton. The flotation process has been applied for the treatment of tailing, and is gradually being improved. The residues containing cobalt are in strong demand. The yield of silver was 4,044,668 oz., worth $3,027,668. The shareholders received $1,800,000. The known ore reserves are estimated to contain 9,153,139 oz. silver, as compared with 8,921,718 oz. the year before. R. B. Watson is general manager, J. J. Denny is head of the research department, and Charles Butters is consulting metallurgist.

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CONTENTS.

EDITORIAL

LITERATURE relating to tungsten and its compounds is scarce. The paper by Mr. H. W. Hutchin, presented to the Cornish Institute of Engineers this month, will therefore prove welcome to the host of investigators and experimenters. Our pages are so congested at present that room cannot be found for a reprint of the paper in the current issue, and it is being held over until July.

COINAGE of new words is an amiable weakness of some of our scientists. Two instances have come to our notice this month in connection with the microscopic study of minerals. Dr. Joseph Murdoch, the American investigator of secondary enrichment, has invented the word "mineralography" for the examination of mineral sections by reflected light, and Professor George Hickling, of Manchester University, speaks of the "micro-petrology" of coal, to denote the microscopic study of thin sections of coal. Surely these new terms are not needed.

NO doubt every tax hits somebody unfairly. The excess profits impost is a case in point, and we have already quoted several instances. Another example is provided by a company hitherto in financial straits owing to the extravagance and incapacity of former administrators, but now prosperous by virtue of a drastic reduction of wasteful expenditure and the greater business ability of the new controllers. The exacting of a tax of 80% of the profits due to savings in outgo is not exactly a reward of merit, but the victims generally take the incident pleasantly, and are, indeed, glad of the opportunity of helping their country.

PURSUING his acceptable policy of publishing interviews with eminent mining men, Mr. T. A. Rickard gives us, in the *Mining and Scientific Press* for May 5, a long autobiography of Mr. D. C. Jackling. The great achievement of this engineer has been the successful treatment of low-grade copper ores, commonly known as the porphyries. To his skill and persistence is due the establishment of big industries at Utah Copper, Nevada Consolidated, Ray, and Chino. More recently he has had in hand the development of the Gastineau gold mines, behind Juneau, Alaska. In this connection he has come in for much criticism owing to the mill returns not substantiating the estimates, and his personal views as to the reliability of methods of sampling extremely low-grade ore-bodies are therefore of particular interest.

THE Cornish Chamber of Mines held its inaugural public meeting at Camborne last month, on which occasion the first members of council were elected. These gentlemen are all chairmen of mining companies: Mr. Frank Harvey, of Dolcoath, Mr. H. M. Rogers, of East Pool, Mr. Francis Allen, of South Crofty, Mr. James Wickett, of Tincroft, Mr. Oliver Wethered, of Geevor, Mr. E. W. Janson, of Porkellis, and Mr. T. Negus, of Grenville. Mr. T. Knowles, who has been long connected with Camborne Mining School in both administrative and teaching capacities, has been elected secretary to the Chamber.

MR. E. A. WALLERS, in his presidential address to the Transvaal Chamber of Mines, calls attention once more to the absurdity of quoting "working profits" as "profits," a habit of some directors who wish to mislead shareholders as to the amount ultimately available as dividend. The individual companies on the Rand and the Chamber itself carefully indicate what is meant by a "working profit." Mr. Wallers draws attention to the increasing number of items in addition to working costs that reduce the divisible profit. During 1916 the working profit of the gold mines of the Transvaal was £11,630,000, being £76,000 more than in 1914, but the dividends declared were a million less, at £7,095,000. Thus only 60% of the working profit came to the shareholders.

WHEN President Wilson brought his country into line with the other champions of civilization, the American engineers domiciled in this country lost no time in organizing themselves into a consultative committee for the purpose of aiding those who are responsible for the military administration. One of the subjects to be studied by the committee is the development of railway communication in Russia and the improvement of methods of transport. Attention is also being directed to the establishment of a grain-growing industry in the Amur district, which would provide a source of food for the Allies. Such grain could be carried cheaply as a return cargo in ships that are at present delivering war supplies to Russia. Another proposition is to encourage the building of wooden ships at certain points along the Siberian sea-board, where timber is plentiful. Any of our readers who are desirous of helping this committee should communicate with Mr. C. W. Purington, at 6 Copthall Avenue, London, E.C.2. It may not be out of place for us to call the attention of the Institution of Mining and Metallurgy to the existence of this committee, and to recommend a cordial co-operation between the two bodies.

DIFFERENCE of opinion exists as to whether dividends should be declared free of income tax or subject to such deduction. Mr. W. F. Turner, in his address to the shareholders of the Anglo-Continental Mines, pointed out that the custom of declaring them free of income tax works to the indirect disadvantage of the company, for the careless observer does not differentiate between the free and subject declarations. In the case of this company, the 10% dividend, free of tax, did not convey a clear idea of the actual earnings. First impressions go a long way, and it is difficult to eradicate them, however much logic is subsequently used. Similar detriment arises from the par value of a share being less than one pound. During the past few weeks we have had two instances of this. In the first case, adverse comment was passed on Ex-Lands Nigeria shares, because they were quoted at only 2s., though that figure happens to be the par value. In the second, the query was put as to the reason for Ashanti Goldfields shares standing at only 19s., the inquirer not being aware of the fact that the par value of those shares is four shillings.

Refractories and Geology.

In our Mining Digest this month we reproduce an important paper on "Refractories," by Mr. Cosmo Johns, which was discussed in considerable detail at the meeting of the Iron and Steel Institute. This discussion, and also that at the symposium of the Faraday Society held a month previously, indicate the enormous amount of interest which is now taken in this subject. This interest may be gauged by the fact that the Faraday discussion was continued into the small hours of the morning, and even then was only suspended by the application of the closure. Another society that is doing excellent work in this direction is the English Ceramic Society, whose secretary, Dr. J. W. Mellor, is at the forefront of research at present. This society appropriately has its headquarters at Stoke-on-Trent, in the midst of the Potteries, but its energies are not confined to the staple manufacture of the district. For instance, a recent paper of wider application was that on "Zirconia as a Refractory," to which short reference was made in our last issue. As far as metallurgists are concerned, this country has allowed Continental rivals to do the bulk of the research work and experiment. We believed the statement that clays suitable for zinc retorts were only found in Belgium and Germany, and we imagined that the beneficence of Nature and not the wit of man was the deciding factor in choosing a clay. As a perusal of Mr. Johns' paper will show, the study of refractories introduces the consideration of a great variety of factors and occasional contradictions. Primarily the requirement for a refractory is the power to withstand great heats, but it is also necessary for the refractory to be unaffected by the charge. Here already we come to an exception, for occasionally it is desirable in copper-smelting practice to use a silicious lining that is actually dissolved by the contents of the furnace. Mr. Johns' paper is not only a sound and practical exposition of a branch of commercial science, but it contains a number of points that might provide food for cogitation on the part of the economic geologist. We find that one of the weaknesses of refractory bricks and linings arises from the molecular inversion of certain materials used in their manufacture. The bricks may be submitted in the furnace to far higher ranges of temperature than those to which they are exposed during manufacture. At these higher temperatures, these substances are converted into others of the same chemical analysis but of different specific gravity, with the consequence that the brick crumbles. A good example of this phenomenon is presented by quartz, which at certain high temperatures is converted into tridymite. Both of these have the chemical formula SiO_2 and are therefore silica, but the specific gravity of quartz is 2·65 and that of tridymite 2·3. It is clear therefore that when inversion takes place the volume occupied by the silica increases, and the structure of the brick is thereby shattered. These molecular rearrangements should not be left out of consideration by the economic geologist when theorizing on the origin of ore deposits or on rock-formation through igneous agency. To put it briefly, it is sometimes better for a geologist to be a metallurgist than to be a mining engineer.

Electric Smelting.

On another page we present an article by Mr. William Dewar, recounting some of his experience in connection with the electric smelting of copper ores. This application of the electric furnace has been little studied, for the reason that standard practice by fire or wet methods usually meets the requirements of the metallurgist sufficiently well. Either the sulphur in the ore supplies some or all of the fuel required for heating purposes and so decreases the carbonaceous fuel to a minimum, or the oxidized ores can be leached as an alternative for smelting. Where carbonaceous fuel is extremely scarce and costly, and where water power is cheap and plentiful, the electric furnace could be profitably used on certain types of sulphide ore, or for the reduction of oxidized ores. The ore on which the experiments described by Mr. Dewar in his article were made was oxidized, the copper occurring as both carbonate and silicate. The problem here was to use electric heat for the purpose of obtaining the temperature required for the reaction between oxide and carbon. The experiments were made in the Keller furnace, at the works of Keller, Leleux & Co., in France, where many trials have been conducted on sulphide and oxidized ores at various times. As we have already said, the application of electric heat to the treatment of copper ores has been limited, but mention should be made of Keeney and Lyon's investigation in America, and of the experiments on a practical scale in Newfoundland. Mr. Dewar's contribution adds to our knowledge of the behaviour of slags, and will be read with interest by metallurgists for that reason.

For the benefit of such of our readers as are not chemists or metallurgists, it may be well to give an outline of the application of the electric furnace. There are five different purposes to which the furnace may be put. In the first place, the heat produced may be employed solely for melting the contents of the furnace, under circumstances where contact with fuel, products of combustion, or other gases is undesirable. Such types of furnace are employed in the manufacture of high-class steels and the copper alloys. A second series of operations are those in which the heat necessary for a chemical reaction is supplied by the electric furnace. In these cases the heat is supplied in this way either as a substitute for carbonaceous fuel where the latter is scarce, as in the smelting of iron or copper ores, or where it is desirable to keep the product out of contact with gases or other products of combustion or dissociation, as in the case of zinc distilling or phosphorus manufacture. In a third class of reactions, the electric current is used not only for heating the charge but in electrolytically overcoming the chemical affinity of the elements constituting the substance treated. A typical example of this class is the aluminium furnace, where alumina, dissolved in cryolite, is dissociated into metal and oxygen. The reaction in this furnace is obscured by the fact that the oxygen combines with the carbon of the electrode, so that it might be imagined that the function of the current was only that of a heat-producer. That the metallurgists are not agreed as to the exact nature of the reactions is evidenced by the recent publication of views by Messrs. Bailey and Seligman. In the fourth class of electric furnace application, we include the production of metals, metalloids, and alloys that require a more intense heat for both melting and chemical reaction than is conveniently obtained in other ways. The production of tungsten and other refractory metals and ferro-alloys may be quoted as an example of this class. Finally we come to the fifth class, where the intense heat of the electric furnace, with concurrent exclusion of gases, produces entirely new compounds, the existence of which was not even suspected. Among the products obtained in this way may be mentioned calcium carbide and carborundum, the latter being a silicide of carbon. Though not exactly fitting the definition, the manufacture of the diamond may be conveniently placed here.

As regards the development of these chemical and metallurgical methods, the basis was the discovery of the electric arc by Sir Humphrey Davy in 1800. During subsequent years many investigators applied the current of the electric battery for melting, and for producing chemical reactions, but it was not until the invention of the dynamo in 1867 that progress on a commercial scale was possible. The pioneers who deserve special mention are Cowles, Hall, and Heroult, who in the eighties were all working on the use of electricity for reducing aluminium. Subsequently Stassano applied the electric furnace to the smelting of iron ores, Moissan investigated the refractory elements, Willson produced calcium carbide, and Acheson discovered carborundum, and made artificial graphite. There are opportunities for electric smelting in the countries endowed with water power. Scandinavia, France, Italy, Germany, the United States, and Canada have many electro-metallurgical centres. The development of the hydro-electric resources of Scotland is baulked by the deerstalkers, and except for the two installations of the British Aluminium Company no progress has been made. We should like to see the possibilities of the water power of Ireland more generally appreciated, for the establishment of an electro-metallurgical industry would remove many of the sad conditions of the distressful country.

The Metric System.

Twice during the last six months the relative advantages of the metric system and the British system of weights and measures have come up for discussion at a general meeting of the Institution of Mining and Metallurgy. In November last we had an informal discussion. The various points for and against were logically put, and the sense of the meeting was generally in favour of making a change. Quite a different spirit reigned over the meeting held on May 24, and a sort of lord of misrule ran riot. It was difficult to tell whether some of the speakers, or even the author of the paper, intended us to take them seriously. Most of their arguments against the adoption of the metric system were in the nature of the chemist's reversible equation, and could have been used equally well, if not with stronger emphasis, in the opposite direction. The paper on which the discussion was based was written by Mr. W. R. Ingalls, the editor of the *Engineering and Mining Journal*, of New York, and it was entitled "Shall Great Britain and America adopt the Metric System?" The introductory note stated that the paper was sent "in the hope of opening the eyes of members to the great danger with which Great Britain and the United States are threatened by the present strong metric propaganda." As we mentioned last month, the tool-makers of America are up in arms against the proposed adoption of the metric system there, a proposal which has been well received and finds favour in all other scientific and technical circles. The objecting parties point to the cost and other inconveniences incidental to the change. They have gone so far as to organize a society called the American Institute of Weights and Measures to combat the arguments of the reformers. Mr. Ingalls has been elected president of this Institute, and thus he becomes the official champion of views which we could never imagine him holding. Of his paper it may be said that, to our mind, his arguments lacked life, that his attitude was one of weariness, and that his specific examples merely reflected the doctrine of "it-can't-be-done." The illogical nature of the paper so struck one of the speakers, Mr. Harry Alcock, a well known champion of the metric system, that, though not a member of the Institution, he came from Manchester especially in the hope of meeting Mr. Ingalls personally and of ascertaining over a pipe in the smoke room whether he had not some other reasons for writing the paper besides those actually put forward. We have said that several speakers were as difficult to follow in their conclusions from certain facts as Mr. Ingalls. This was all the more remarkable seeing that they were men of wide experience and consummate erudition. All the remarks made at the meeting were in excellent temper, and several speakers humorously apologized for their apparently scathing remarks as to the mental capacity of their opponents. Our own remarks are made in the same Pickwickian spirit.

There are a number of points in connection with the discussion to which we should like to make reference. In the first place our experience tends to show that the cost of the change is greatly exaggerated. Thirty years ago the present editor of this Magazine, when a student at Owens College, Manchester, shared in some investigations at a number of works in the neighbourhood as to the cost and inconvenience that would be involved. The general view of the engineers was that little inconvenience and cost would be involved if the change was spread over five years. Their chief worry was that the directors and big shareholders always jibbed at any expense, however small. They desired us, the inquirers, to invent some way of accounting for the cost in such a manner that it should not appear in the profit and loss account or the balance-sheet, and thus that the night's rest of the moneyed men should not be disturbed. It was generally felt that the spreading of the cost over several years would help them in this way. During these investigations, a good example of the inconveniences of the present method of handling foreign orders came before our notice. A Belgian firm had ordered a large number of a particular machine made in a series of sizes. The dimensions were in millimetres. These had to be converted into inches and decimals, and the nearest $\frac{1}{64}$th fixed on. After manufacture, the dimensions had to be re-converted into the exact millimetres and decimals corresponding to the English measures in 64ths. There was not the slightest reason why the parts should not have been made to the buyer's original measurements, except the law of the Medes and Persians. Such things had always been made in English inches and fractions, and not even a nonsensical system of weights and measures could overthrow British superiority in manufacture. This incident brings us to another point which we wish to make, namely, that the chief person to benefit by the change to the metric system is the manufacturer himself, for the simplicity of the system reduces the amount of mental labour to an extent not readily appreciated at first. So many of the dissenting manufacturers consider the change as a bitter pill to be swallowed for somebody else's benefit, being quite ignorant of the fact that are themselves the chief beneficiaries.

An aspect of the present complicated system of weights and measures, in connection with the sale of certain classes of commodities other than machinery, that is often overlooked is that complications of units are specially fostered to mystify the buyer and to preserve the sanctity of the trade secret. Those tons of 21 cwt. in the ore trade, the butcher's stone of 8 lb., and the corn-merchant's quarters all seem to have been invented for the purpose of keeping the public in the dark. The establishment of simpler standards would bring producer and consumer into closer contact. In pursuing this aspect of the subject it becomes clear that the advantage of a change to the simpler system accrues chiefly to the user of the article as contrasted with the seller, so that in considering the possibility of the change, it is not necessarily in the interests of the community at large to consult the convenience of those who have their own selfish reasons for resisting any alteration. The most strenuous opposition to daylight saving came from the gas and electric light companies, who saw their outputs threatened, and who therefore sought to prove that too much daylight was bad for the human constitution.

We were astonished to hear several speakers at the meeting allege that the English system of weights and measures has as scientific a basis as the French. It is true that the fluid ounce of water weighs one ounce avoirdupois, and that the imperial gallon of water weighs ten pounds. But who ever wishes to measure wood or iron by the gallon? The measure of capacity should be founded on the cube of a linear unit, and not on weight, and this is not so with the English units. Just because the original calculation of the metre as one ten-millionth part of the earth's quadrant proved ultimately to be slightly incorrect, it does not follow that the whole system is unscientific.

It is possible, as some speakers proposed, to reform the English system by making illegal the use of many of the illogical and inconvenient standards, and thus reducing the range of units. The difficulty here is that various trades and professions would be hit unequally, and opposition would come from those who had cause to resent unfair treatment. The surveyor would object to the abolition of the rod and chain, for it would cause him inconvenience, and he would be envious of the draper who would still sell his goods by the yard without having had to rearrange his standards. Other half-way reformers suggest that English units should be retained but their sub-division decimalized. In this way the reformers are mostly self-contradictory, for one of the advantages of the English system urged by them is the convenience of even fractions of eighths or twelfths. To this proposal to decimalize English units we would say that it is no use taking the trouble to make an alteration unless full benefits are obtained.

A valid point made by the opponents of the metric system is that under many conditions the units are too widely separated. For instance, some convenient unit is wanted between the gramme and the kilogramme. The nomenclature of the metric system is just a little too logical, and the uniformity of the words with their varying prefixes introduces confusion and irritation. We have already contracted kilogrammes to "kilos." We now want a slang word for the hectogramme, which could then come into general use in connection with small purchases, especially in these days of rationing. The 100 kilogramme unit known as the metric "quintal" is not altogether a satisfactory term, and the word would be better employed to connote 50 kilogrammes as a substitute for a hundredweight, as it used to be in the Latin countries. Similarly it may be objected that there is too great a gap between the millimetre and the metre. It is true that the centimetre is employed for most measurements where the inch is the usual unit, but it would be convenient to re-christen the decimetre and use it in measurements where the foot has hitherto been the most suitable unit.

Some of our readers may smile at whole-hearted supporters of the metric system as we are making individual proposals, but our suggestions are expressly brought forward to remove one of the real grievances of the "antis." We have on several occasions expressed our adherence to the metric system and to the policy of early change. We invite men of experience and position to lead the world in reforms and to 'educate' the masses, rather than defer to the manners and customs of the street. One speaker the other evening told us that even in France the metric system was not universally used, and that you could still buy vegetables in the street market at so many "sous" per "livre." After the meeting, a kerbstone merchant offered us a "bundle" of asparagus for "three bob and a tanner," but his nomenclature did not shake our belief in the advantages of the metric system.

John Neville Maskelyne.

It may appear out of place to refer in the pages of a mining paper to the death of a man who was chiefly known as a dealer in mysteries and as a public entertainer. But the late J. N. Maskelyne was far more than that. He was a great mechanician and scientist, an exposer of charlatans and humbugs, and an apostle of physical dexterity and mental agility. The average person was apt to consider Maskelyne's entertainment as a pleasant, harmless little function to which the modern girl could safely take her maiden aunt. Such an attitude was in itself a living instance of that lack of the power of observation which it was the famous entertainer's ambition to combat. As a matter of fact the Egyptian Hall, and later the St. George's Hall, were, under his guidance, great educational centres, and many a youth has thereby discovered the art of seeing a thing when he looks at it, and of deducing the cause of puzzling phenomena. In some cases the effects were obtained by methods which are quite simple when explained, a fact that reflects our more that occasional inability to identify the cause of a simple circumstance, or to extract from it a useful deduction. In other cases the so-called tricks were performed by extraordinary mental ability, which had been cultivated by long and systematic training; though in this department of the art he was surpassed by the famous Frenchman, Robert-Houdin. Of the examples of manual and physical dexterity exhibited the public were better able to judge, or at least to appreciate their influence. It seems to us that the exceptional cultivation of the brain and body exemplified in Maskelyne and his friends foreshadow the possibilities of future developments of the mind and muscle on a scale commensurate with the advancement of what we may call micro-science. Delicate touch and great mental nimbleness are required for the elucidation of modern physical and chemical problems. Hard gymnastics and military training are necessary as a preparation for facing the gigantic applications of the forces of nature, but different methods must be used for the elucidation of the inner meaning of these forces.

Maskelyne was not recognized by any of the influential engineering or scientific societies, and he was thus in the same position as Mr. Barker, the bone-setter, who, though a man of consummate skill, is prevented from attending to the wounded soldiers owing to the wording of the charter of the Royal College of Surgeons, and the tenacious method of its application by those in authority. None the less, Maskelyne was a pioneer of science, and he was always years ahead of the Royal Institution's Friday evenings and Christmas lectures in his exposition of scientific wonders.

We have spoken of his services as an exposer of humbugs. Most of us are too young to remember his campaign against the spirit rappers, table turners, and cabinet tricksters of days gone by, or even of his endeavours to show the absurdities of the false theosophists who claimed connection with the inaccessible regions of Thibet. These various imposters claimed supernatural power, and hosts of people in this country and elsewhere were believers. Maskelyne produced the same effects, and told his audiences that they were produced by ordinary human skill combined with ingenious mechanism. He did a great service in thus freeing the public from a haunting fear, and in demonstrating the usual reliability of well known natural laws. In later life he learned to take a gentler view of human nature, and he admitted that, after all, the ordinary person likes to be deluded, framing many of his entertainments accordingly. His experience in this direction coincides with those who attempt to prove the absurdity of many of the propositions in connection with mining speculation on the Stock Exchange or the futility of making a bet on the race-course against a well informed bookie. But his influence in the latter days, though not so energetic as in his youth, was just as effective, and he had the gratification of knowing that spirit rapping and crystal gazing had been relegated to the supervision of the police. Wild mining speculation and betting on horses we still have with us, though they are both curtailed by war conditions. No doubt the public will continue to cling to these fond illusions.

Maskelyne's great service was in inculcating observation and in cultivating mental agility and alertness among his multitude of pupils. Can anyone imagine such a man flourishing in Germany? More is required than a mere amassing and classification of knowledge. A keen intelligence and a ready wit are also desirable, and the possession of them would have prevented the many egregious errors of judgment on the part of the Germans during the present war.

REVIEW OF MINING

Introductory.—The outstanding feature of the month has been the rise in the price of tin. As recorded in our last issue, the quotation began going up about the beginning of May. By the 25th of the month the official price had risen to £255. Subsequently the situation became eased, and at the time of writing (June 11) the quotation has receded to £238. It is stated in some quarters that the loss of tin due to submarine activity is accountable for the temporary squeeze; this is open to doubt, and much of the firmness may be attributed to the increasing demand from America. Another event of note has been the appointment of a Government committee to consider the various plans for the establishment of the Imperial Mineral Resources Bureau. It is gratifying to find that the Government has lost no time in adopting the suggestions of the Imperial War Conference, to which we referred last month.

Transvaal.—For some months the available labour supply at the gold mines has been diminishing, owing presumably to recruiting for the labour battalions for European service. The number reported at work at the end of May was 180,168, as compared with 199,330 six months previously. The scarcity is reflected in the monthly yields. The total output on the Rand during May was 753,351 oz. as compared with 760,598 oz. in March and 751,198 oz. in May 1916. The labour position is well indicated in the yearly reports issued last month by the various South African groups.

The Union Government has offered additional gold-mining areas in the Far East Rand for tender. The areas include 2,050 claims constituting Springs farm, 2,526 claims on Eastern Geduld farm, and 4,672 claims on Rietfontein farm. To avoid customary confusion we remind readers that Springs Mines is not on Springs farm, but in the north-east corner of Rietfontein.

The gold-mining rights belonging to the New Geduld Deep have been sold to the Consolidated Mines Selection, and the purchase price is 17,500 shares in Springs Mines Limited. The property covers 172½ claims and is situated south of the Geduld, separated from Springs Mines by the triangular strip constituting Springs farm. The property is in the centre of the area that has been offered on lease by the Government.

It will be remembered that the quality of the ore developed in the early days at the Government Gold Mining Areas was disappointing. The position has more recently substantially improved in this respect. The yield per ton during 1916 was 27s. 1d., and in December it was 29s. The reserve on December 31 was estimated at 4,930,000 tons averaging 7·2 dwt. over 75 inches, as compared with 3,665,000 tons, 6·9 dwt., and 68 inches the year before.

The last quarterly report of the New Modderfontein shows that 88% of the ground developed was payable, averaging 51 dwt. over 12 inches. It is expected that the new treatment plant for the South shaft installation will be ready in November.

The best development report so far issued by the Daggafontein Mines was published at the beginning of this month. In the western section, a length of 150 ft. driven sampled 38 dwt. over 19 inches, and at another point the average was 55 dwt. over 16 inches.

The Van Ryn Deep has always been an excellent property. The report for 1916 shows that the position has become even stronger. The elimination of waste has been studied, and the percentage rejected at surface has been increased to 18·6%. The amount of ore mined was 80,000 tons greater than in 1915, and the tonnage milled 23,440 tons more. The reserve is estimated at 2,168,000 tons, averaging 8·7 dwt. over 68 inches, as compared with 2,044,000 tons, 8·4 dwt., and 62 inches the year before. Unlike some of its neighbours, Van Ryn Deep is a comparatively dry mine, and the water pumped is barely sufficient for the surface plant.

As recorded on several occasions, the southern section of Knights, belonging to the Witwatersrand Gold Mining Co., is being developed as an independent deep level. The ore disclosed is on the whole satisfactory. It is notable that the Main Reef contains workable stretches of payable ore, though hitherto development has been confined to the South Reef.

The Bantjes Consolidated mine made a loss during 1916, but the recent developments on the Main Reef Leader give encouragement for further development. It is now announced that arrangements have been made to provide additional working capital by means of a loan carrying 6½% interest. Shaft-sinking is accordingly to be resumed.

The Meyer & Charlton continues to remind us of the palmy days of the central Rand when the grade of ore treated could be reckoned by ounces instead of pennyweights per ton. The particulars of ore reserve now published show that 312,996 tons in the Main Reef Leader average 20·5 dwt. per ton over 46 inches. These figures compare with 273,900 tons, 18·4 dwt., and 46 inches at the end of 1915. The consumption of zinc in the cyanide plant has been reduced recently. A sufficiency of precipitated gold is kept in the zinc-boxes, thus avoiding cleaning up before the gold-bearing zinc is decomposed, and improved methods of cutting the zinc have been introduced. During 1916 the consumption of zinc was 84,945 lb. as compared with 59,958 lb. in 1914, the gold recovered in the cyanide plant being 57,253 oz. in 1916 and 53,090 oz. in 1914.

Developments at the Consolidated Langlaagte have not given such good results lately. During 1916 a greatly increased scale of development became necessary in order to maintain the reserve. Recent experience indicates that the percentage of payability will not be so high in the lower levels as it was nearer the dyke. This is particularly the case in the Main Reef Leader. The results have been better in the South Reef, though here also the ore is rather patchy.

The Durban Roodepoort mine enjoys the honour of having been the only consistent dividend payer in the Roodepoort section of the Rand. The company was never associated with any of the big groups, but ploughed its lonely furrow, having the good fortune to possess in Mr. (now Sir) H. Ross Skinner an excellent manager and consulting engineer. The first dividend was paid in 1889, and the total distribution to date has been 1,200%. The mine is rapidly nearing exhaustion. On December 31 last the remaining ore was estimated at 135,060 tons, sufficient to last eight months at the former rate of extraction. Owing to the restricted number of working faces, the customary rate will not be maintained, so that work will probably continue throughout the current year.

The bewaarplaatsen question appears to be on the point of settlement, after having provided a controversy ever since the beginning of gold-mining operations on the Rand. In the early days the mining companies acquired surface rights at places away from the mining claims, to be used for offices, dwellings, and dumps, and mining underneath was prohibited. As mining proceeded in depth, the undermining rights became valuable, and the various companies had to bargain with the Government. As a rule a series of annual payments were made to the Government, but the share due to the owners of the freeholds was never settled. The bill under discussion provides that 19/40ths of the amount paid shall go to the old freeholders, and that 18/40ths shall be the proportion in future agreements. These amounts are not to be paid in cash, but in Union stock.

Rhodesia. — The output of gold during April was worth £297,977, as compared with £330,183 in March, and £339,386 in April last year. Bell Reef and Golden Kopje have fallen out of the list of producers.

The directors of the Shamva Mines announce that the ore recently discovered is of lower grade than that in the main body, but that it is extensive and will substantially increase the life of the property. The lower-grade ore is to be mined concurrently, so that the average yield per ton sent to the mill will be reduced. Shareholders are informed that they may expect dividends at the rate of 25% per year, instead of the 30% to which they have been accustomed for the last year and a half.

Hearing of the appeal by the Amalgamated Properties of Rhodesia against Mr. Justice Eve's judgment in favour of the Globe & Phœnix was commenced on June 6, and the case is likely to occupy the court until the Long Vacation. Some preliminary skirmishing took place in Chancery in connection with the security for costs in the first action. The Amalgamated Properties gave the necessary security and thus escaped being placed in the hands of a receiver.

For a long time the fate of the Giant mine has been in the balance. The ore was lost at depth, and expert advice failed to recover the ore-body. There was no alternative but to seek a new property and to exhaust the remaining ore. The Cam–Good Shepherd claims were bought from the Cam & Motor. News now comes that the Giant mine is to be closed down. The April results were 7,500 tons for a yield of £2,126, or 5s. 8d. per ton, and a working cost of £3,368, or 9s. per ton. Under such circumstances a suspension was inevitable.

West Africa.—The output of gold during April was worth £123,825, a figure lower than recent averages owing to a decrease in the output at Abbontiakoon.

Nigeria. — The Mongu Tin Mines company announces the acquirement of the Benue dredge. This has been moved to the company's property and re-erected there.

Australasia.—In a recent issue we noted that Mr. E. C. Dyason had proposed a scheme for amalgamating the forty companies operating gold properties in the Bendigo district. It is now announced that 38 of the 40 companies have agreed to terms, and that a company called the Bendigo Amalgamated Goldfields is to be formed. Mr. Dyason and the companies were helped in the negotiations by a Committee of Assessors, various members of which were appointed by the Ministry of Mines, the Bendigo Chambers of Mines, and the Bendigo Stock Exchange.

We reported in our January issue that the British Broken Hill company had made arrangements to reopen the mine, at which work was suspended at the commencement of the war. The mill was started at the end of January with two shifts per day, and a month later three shifts were inaugurated. It will be remembered that the mill had been remodelled and enlarged just before the war. From the recommencement of operations to May 31, the amount of ore treated was 46,505 tons, from which was produced 4,628 tons of lead concentrate and 7,550 tons of zinc concentrate. Mr. C. J. Emery, the manager, reports the plant to be working well, and states that further improvements are being continually made. The directors have declared an interim dividend of 1s. per share, absorbing £18,750.

For some time it has been known that the Great Boulder Perseverance is not likely to yield any more ore in depth. Additional ore has, however, been found in a new lode known as the "X," which is being developed on the 700 ft. and 900 ft. levels. On the 900 ft. level the ore is payable for a length of 500 ft. On the 700 ft. level, a length of 200 ft. has been proved averaging 35s. per ton. Owing to scarcity of labour, the mill has not been kept working to capacity, with the consequence that during 1916 the expenses were not quite met. During 1916, the yield was £205,678 from 194,106 tons.

The Sons of Gwalia report for 1916 shows that the ore-body continues to develop satisfactorily at depth, though the average assay-value is rather lower. The ore reserve has slightly increased and stands at about 4½ years supply. The 24th level is being opened. During 1916, the ore treated was 158,956 tons, and the gold extracted was worth £232,923, of which £40,625 was distributed as dividend, being at the rate of 12½%. The company is now doing its own work in connection with cutting firewood, instead of letting the business on contract, with the gratifying result that the cost of fuel is much lower.

Labour scarcity is acute in Australia. For instance, extraction of ore at the Mount Boppy gold mine at Cobar has been suspended until conditions improve. In the meantime, a new shaft is to be sunk in the country rock, in order that extensive reserves around the present shaft, and in other parts where the ground is unsafe, may be worked. Development has disclosed ore of lower grade lately. The mine has on several occasions suffered either from drought or from excessive rainfall.

Canada.—Operations at Porcupine have been hampered by the scarcity and inefficiency of labour. The unskilled workmen employed at the mines are mostly alien enemies, many of whom have been released from internment camps, and are disposed to be insubordinate. The Canadian Government recently ordered a census of alien enemies in the Northern Ontario mining districts to be taken, and has threatened to again intern any who became troublesome and refused to work. This action has had a quieting effect. The Hollinger Consolidated, in spite of these difficulties, is pushing construction on its new equipment, which will increase the milling capacity by 1,000 tons daily. The additional plant is expected to be completed about the end of June. Vein No. 58, which is being followed up on the 425 ft. level, continues to yield rich ore and the reserves have been substantially increased.

Mine owners at Cobalt have been encouraged by the high price of silver to maintain production vigorously. The grade of ore is gradually declining with the exhaustion of the richer deposits, and the continuance of the industry requires the adoption of economical methods. The most noticeable feature in this direction is the general adoption of the flotation process for the treatment of tailing. The McKinley-Darragh, which has a 100 ton flotation plant in successful operation, is preparing to install another flotation plant of 250 ton capacity. Grinding is to be done in Marathon mills, in which rods are employed in place of balls or pebbles as described in our issue of September 1916. The use of the flotation process by the Cobalt companies threatens to give rise to litigation, as Minerals Separation has notified the Dominion Reduction Co. that it claims the use to be an infringement of its patent rights.

Labour troubles at the British Columbian coal mines have caused a scarcity of coke, so that the Consolidated Mining & Smelting Company of Canada has closed the gold-copper department at the Trail smelter. As a consequence, mining at the War Eagle, Centre Star, and Le Roi at Rossland has been suspended. The lead-smelting department is still at work, and the ores from the Sullivan and other mines continue to be treated. The Rossland mines have also suffered from labour troubles, and this condition no doubt had some influence in the decision to close down. The Le Roi No. 2 company has also had labour troubles, but has managed to keep going, though operations have been greatly inconvenienced by the stoppage of the Trail smelter, where its ores were treated. There are, however, other possible outlets for the ore in case the Trail smelter remains closed.

United States.—The figures for the output of lead during 1916 show that 596,221 short tons was produced from home ores, 218,253 tons coming from Missouri, 170,059 tons from Idaho, and 111,798 tons from Utah. The corresponding output during 1915 was 537,012 tons. The output of zinc during 1916 from home ores was 563,451 tons as compared with 458,135 tons in 1915 and 343,418 tons in 1914; and from imported ores 104,005 tons as compared with 31,384 tons in 1915, and 9,631 tons in 1914. As regards the source of imported ores, 41,958 tons of zinc was produced from Australian ores, 24,376 tons from Canadian ores, and 20,694 tons from Mexican ores.

Malay.—The Tronoh report shows that the chief portions of the mine, notably the south lombong, workable by open-cut, are exhausted, No. 3 section being the only part left. Here, however, the bores recently put down have indicated the presence of gravel of higher average content. On the other hand the company owns extensive tracts that can be worked by bucket-dredge, and there are good chances of proving additional profitable ground. The directors have prepared a plan for providing another dredge to work No. 6 section, but war conditions have stood in the way so far. At the present time, the output comes from sluicing at No. 3, from Nos. 1 and 2 dredges, and from tributers. The total output of tin concentrate during 1916 was 1,647 tons, of which half was obtained by tributers, a quarter by open-cut mining, and a quarter by dredging. Dividends absorbed £35,000, or 20%.

The Tronoh has a controlling interest in the Sungei Besi company, which operates an alluvial tin property in Selangor. The output there during 1916 was less than for 1915, owing to time being occupied in changing over from one section to another. The yield was 414 tons of tin concentrate, and the profit distributed was £5,570. There is every expectation of a substantial increase in the output, and a profitable future is anticipated.

A record of the results for 1916 at the Ipoh Tin Dredging Co's. property is given elsewhere in this issue. Operations have been made difficult by the clayey nature of the ground, and as the clay does not get entirely broken up in the screen, a good deal of the cassiterite is carried away in the rejected material. In fact the average recovery has been only 65%, though when the ground is free from clay the figure rises to 90%. The wear on the screen and buckets is very great. Boring has been continued systematically, with varying results. Part of the land has been proved unprofitable, but on the other hand 100 acres is found to average 1·2 lb. per yard, and may warrant the provision of another dredge. A block of land on the other side of the railway has been bought, and this also shows an average of 1·2 lb. per yard. Additional adjoining land is being examined.

Sumatra.—The Shell company announces that in the oil land controlled by it and the Royal Dutch company a new well has been opened yielding a daily flow of 1,200 tons of oil of very low specific gravity. The well is on virgin ground, and the discovery of the deposit is considered to have an important bearing on the future of the Sumatra oil industry. It may be of interest to state that Shell No. 1 spirit comes from Sumatra oil.

Russia.—The report of the Lena Goldfields for 1916 confirms the previous circulars to the effect that the Imperial & Foreign Corporation, the Russian & English Bank, and Mr. G. Benenson were desirous of securing the control of the gold mines. This group offered to buy 57,000 shares in the Lenskoie company, the Russian company owning and managing the property, from the Lena Goldfields, and also to buy 246,703 shares, hitherto unissued, in the Lena Goldfields, the latter purchase being proposed with the object of obtaining control of the Lena Goldfields. The purchases are to be made at £30 for each Lenskoie share and 32s. 6d. for each Lena Goldfields share. The payments are to be made by instalment. There have been considerable differences in opinion between the Lena Goldfields and the Lenskoie company, and between the respective engineers of the two companies, as to the method of working the deposits. Mr. C. W. Purington, the engineer for the Lena Goldfields, expresses his opinions freely in his report adversely to the mining policy of the Lenskoie, drawing attention to the inordinately high costs and the inadequate provision of gold-saving appliances. The Lenskoie managers, Messrs. Graumann, Thorne, and Weis, have prepared plans for working certain placers by means of a large dredge, some particulars of which are given elsewhere in this issue.

ELECTRIC SMELTING OF COPPER ORES

By W. DEWAR, M.Inst.M.M.

The author discusses the possibility of applying electric current to the smelting of copper ores, and gives the results of tests on a silicious ore containing copper as silicate, oxide, and carbonate.

INTRODUCTORY.—Smelting is the art of rendering ores fluid by the admixture of proper fluxes and the application of heat, so as to concentrate the desired metal or metallurgical product in the minimum quantity of valuable material, and eliminate extraneous matter to the greatest possible extent, the new combinations separating in the furnace according to their specific gravities and being drawn off separately. To generate the heat, carbonaceous fuel either solid, liquid, or gaseous, and electric current can be used. With the continual improvement in the construction and design of electro-metallurgical plant, together with the importance and the availability of electric power, especially hydro-electric, the smelting of non-ferrous metals by electric heat is a subject well worthy of attention by those who are interested in metallurgical progress. The van of progress has so far lain with the Continent and America, due no doubt to the greater availability of water power.

Ore deposits may be situated in mountainous districts, or may be inaccessible by railway, the price of coke for smelting may be too high, or the coke unobtainable, or the transport of the ore to a suitable reduction works may be too costly. On the other hand, sufficient water power may be available, from which electric power can be developed at a reasonable figure. It is much cheaper to carry wires over hilly districts than to transport carbonaceous fuel over the same ground. So that, prima facie, the field for electric smelting is where deposits are situated in regions in which coke is costly and hydro-electric power comparatively cheap.

The thermal efficiency of the coke-fired blast-furnace is about 50%, and that of the electric furnace 70%; the cost of coke and electric energy are about on a par when the ratio of the price of coke per ton to that of power per kilowatt-year is in the neighbourhood of 1 : 1·8, neglecting the value of electrode consumption per ton of ore treated. In ordinary smelting, two-thirds of the fuel is used for heating, and the remainder for reduction. The electric furnace requires only sufficient fuel to reduce the metal, and is practically only a heat producer. Its value as a substitute for the combustion furnace, where conditions are such as to warrant its use, would depend on the relative cost of carbonaceous fuel and electric power.

The use of electro-thermic means for treating copper ores has been proposed in recent years, and in a number of cases experimentally tested. Speaking generally, outside of smelting iron ores, the manufacture of aluminium, and the production of steels and of ferro-alloys, electric smelting is still in the experimental stage. There are, however, some other successful applications, of which little has appeared in the press, such as the production of zinc fume, which at present commands a record price, the reduction of tin ores and tin-bearing materials, and cyanide precipitates, and in a small way the production of black copper.

Native copper, oxidized, and, to a certain extent, sulphide ores can be smelted just as efficiently as in the reverberatory or blast-furnace, as the reactions desired can be obtained equally as well in either of these furnaces. Success depends not so much on whether certain chemical or electrical results can be obtained, as to whether they can be secured on commercial lines, and that accompanying and undesirable metals can be held back in the resulting product. The electric furnace does not lend itself to an oxidizing smelt, and is particularly unsuited for the treatment of those sulphide ores which can be smelted with a consumption of a small proportion of fuel. The only part likely to affect the reactions chemically is the lining of the furnace so that the action in the furnace would be confined principally to the combining of the silica with such bases as are already oxidized, and, where necessary, those added as a flux to form the desired slag. Higher refractory slags can be produced in the electric furnace than would be possible in blast-furnace work, but in order to get metal or matte free from impurities certain slags must be run, and it is owing to the lack in this particular that unsatisfactory results have been obtained in the past with experimental trials. The worthy pioneers in this class of work have been for the most part engaged in the manufacture of ferro-alloys. The production of such alloys and the furnaces used are in no way analogous to the process and plant for the treatment of ores. The slag produced in ferro-alloy manufacture is to all intents and purposes negligible, practically the whole of the solid product being of a valuable character.

Native copper or oxidized ores can be smelted direct to black copper, and lean sulphides to a high-grade matte, in one operation. Those containing sulphur in excess for that required for the matte might be partly and cheaply roasted to remove the surplus, or mixed with oxidized ores to obtain the same result. Where oxidized, semi-oxidized, and sulphide ores are available, matte production would probably be the best line of procedure to adopt. Modifications and variations in order to achieve the greatest efficiency and profit for any particular ore or combinations of ores are so entirely dependent on local conditions that the subject can only be briefly outlined in a very cursory manner. What might be good metallurgy in one place might be unprofitable or unwise in another.

One important point to be considered is that charcoal is essential for reduction of the metal from oxide, so that it is necessary for the operation to be in close proximity to a well timbered region where charcoal can be produced at a reasonable cost. Coke is not satisfactory as a reducer, being too dense. It makes undesirable electrical conditions, and causes too high electrode losses in the furnaces; it creates crusts between the electrodes, sows the furnace, and with slags high in lime has the tendency to form carbide.

In the design of an electric furnace, the aim is to obtain the highest efficiency compatible with the operating conditions. The amount of heat necessary to achieve the results desired in any metallurgical process can be determined, and in order to obtain and maintain this temperature a definite rate of heating is essential, this rate depending on the speed at which the heat is conducted away through the furnace walls, the dimensions of the furnace, and the cooling effect of the charge that is periodically added. The relative loss of heat through the walls is less for a large furnace than for a small one, so that each unit should be as large as possible, consistent with the nature of the material treated in the furnace. Where possible it is preferable to employ a continuous process, or, if intermittent, to have small delays between charging. The first consideration is to construct the furnace so as to obtain the greatest percentage of heat value from the electric energy supplied. The dimensions of the electrodes, the section of the furnace best adapted for the operations, and the most suitable tension and intensity are points to be worked out.

For a direct current the power supplied to a furnace in watts is the product of the amperes multiplied by the volts, whereas for an alternating current it is the result of the amperes multiplied by the volts multiplied by the power factor, which varies with the furnace construction. Alternating current is used almost entirely in furnace work. The power may be kept constant by low voltage and high amperage or vice versa. Large amperage means large conductors, thereby increasing the cost of cables, transformers, electrodes, etc. High voltage, though economical, is generally not feasible, as most furnaces have a low electrical resistance. There are two ways of regulating current; firstly, raising or lowering the electrodes, and second, these are kept stationary and the voltage varied by means of variable voltage transformers.

Furnace linings may be classed as acid, basic, and neutral. First, with regard to acid linings available. Good silica bricks should contain about 95% SiO_2. Dinas bricks are somewhat friable and brittle, and do not stand abrasion. These differ from the ordinary silica bricks in the binder employed. Ganister is generally used as a loose material which is tamped into place as a furnace bottom. Fire-clay may be either acid or neutral owing to the different proportions of the silica and aluminous contents; the combination of these should equal about 95% of the clay. Given the same chemical composition, a brick from a fine-grained clay is not as refractory as one made from material in which there is a large proportion of coarse particles.

There are a number of basic materials suitable as lining. Magnesia bricks are manufactured by mixing 90% dead-burnt magnesite with 10% incompletely calcined, the latter being added to effect the setting of the brick. The objections to the MgO bricks are that they expand on heating and flake off when subjected to sudden variations of temperature, and are also liable to crumble when subjected to a heavy load when hot. Bauxite can be used for basic or neutral linings. For basic, the SiO_2 contents should be not much over 10%. It must be thoroughly calcined, otherwise it will shrink at furnace temperatures. It requires Fe_2O_3 to make a firm brick. Lime is not used as a lining, owing to the rapidity with which it slakes when exposed to the air. Of neutral linings may be mentioned carbon, which is one of the most highly refractory materials known. It can be used in the form of lamp black or retort carbon, mixed with tar and rammed in position. Chromite is extremely infusible, but is not suitable for furnace bottoms as it will not stand mechanical erosion. It is, however, suitable for furnace walls above the slag line. Alundum can be used as a lining, and is made by fusing bauxite in the electric furnace. Carborundum is also employed. It is made by mixing coal, saw-dust, and silica and heating in an electric furnace at a high temperature. This material is crushed and mixed with a suitable binder.

THE ELECTRIC WORKS.—The trials on an oxidized copper ore which are recorded hereafter were undertaken at the works of Messrs. Keller, Leleux & Co., at Livet, Isere, France. These are situated about 20 miles from Grenoble, on the main line of the Paris, Lyons, and Marseilles Railway, and are connected to Livet by an electric and steam tramway. Power is obtained from the Romanche river, the water being brought at a head of 60 metres through a tunnel 1,700 metres long. At high water 20,500 h.p. is available, but from November to March this drops to half, when some of the furnaces are shut down and others operated with reduced power.

The installation comprised:

- 3 units 3,000 h.p., 3-phase, 4,000 volts.
- 1 unit 4,000 h.p., 3-phase, 5,000 volts.
- 5 units 1,300 h.p., single phase.
- 4 units 200 h.p., continuous current for general purposes.

The furnaces directly connected to the single-phase generators receive current at 50 volts, 50 cycles, at the furnace. Those on the 3-phase circuit have a single-phase transformer to each furnace and the volts vary from 50 to 70 at the furnace. The 3-phase machines are connected in parallel, and generate current of 25 cycles. The works produce calcium carbide, ferro-silicon, ferro-chrome, ferro-tungsten, and ferro-vanadium. The power cost is £2·18 to £2·75 per kilowatt-year, or 0·059d. to 0·073d. per kilowatt-hour.

THE ELECTRIC FURNACE.—The furnace employed in the copper-ore experiment was of the resistence type such as is used in their regular work of alloy manufacture, and of 600 to 700 kilowatts, with slight alteration of the tap-holes. These tap-holes were two in number, one for the slag, and the other for drawing off the metal. Briefly described, the furnace is a rectangular iron casing lined with refractory brick; at the bottom and along the centre for its greater length a carbon sole exists, made by ramming, while still hot, a mixture of anthracite and tar. This sole is in electrical communication with the exterior of the furnace by means of an iron rod. This connection is essential to avoid the breaking of the current while casting metal, which would interfere with the working of the furnace. The operation of the furnace is therefore continuous and it is not interrupted in any way by charging or casting. The statistical figures obtained in these experiments are given in Tables I, II, III, the details of these being in reference to the discussion following.

The electrodes, two in number, to which the electric current is distributed, are suspended in the furnace, and can be lowered for any required extent of their length. The regulation of the electric input is effected chiefly by the vertical adjustment of these. This is easily accomplished and requires little attention, the man on the feed floor being responsible for this duty. The current passes through the charge between the suspended electrodes and the carbon sole. The energy of the current is absorbed by the resistance of the charge, which is thereby heated to the temperature required for the reduction. The use of the resistence of the charge as a means of heating makes it possible to control the temperature of the work, within certain limits, by controlling the current. The charging of the furnace was done by hand. The charge was shot on to the feed floor, which was on a level with the top of the furnace. The furnace was kept full by shovelling the charge in, as and when required. It worked with open top, and the gases were allowed to escape and burn. The lining was badly eaten away during the tests, due more to physical than chemical action between the slag and the lining, though the extraordinary quick drying of the furnace for lot 2 was also to a great extent responsible for the deterioration of the furnace. Pieces of lining came away with slag at times, and the tap-holes were badly eaten away by the end of the trials. The wear and tear of a furnace is to a great extent a question of design, and the mechanical defects could be overcome by a furnace more suitable for the purpose; increase in the depth and provision of water jackets at the sides of the furnace would be beneficial. The iron casing showed the following variation during the 2nd campaign: temperature at commencement 19°C; 1st day 65°C; 2nd 76°C; 3rd 89°C; 4th 103°C; 5th 110°C.

ORE, FLUX, AND FUEL.—The ore was a highly silicious oxidized ore, and was crushed to pass a 1 in. ring. The flux used was lime, with the exception of the last mixture in the second trial of 5,000 kilos, which was run with limestone. The lime used in the trials was somewhat old and had a large proportion of fines. Extremely fine particles are detrimental, as they tend to block passages, cool the charge, and increase the power required. The fuel used was charcoal in good physical condition, the pieces being about 2 in. in size. In the mixture with limestone, coke was substituted for charcoal. The ore, flux, and fuel after being weighed were mechanically mixed before going to the feed floor. The analysis of these materials will be found in the statement in Table IV.

THE TESTS.—These were two in number. The first was started on a hot furnace, which had been heated up for a couple of days on old slag, but the run was cut short owing to the inability to tap metal, the tap-hole being too high to accomplish this. The run lasted for two days. For the second campaign, the furnace was rebuilt and the metal tap-hole lowered. It was then dried by a wood fire, and the furnace started by adding a small quantity of copper

TABLE IV.—GENERAL ANALYSES.

1. Ore.

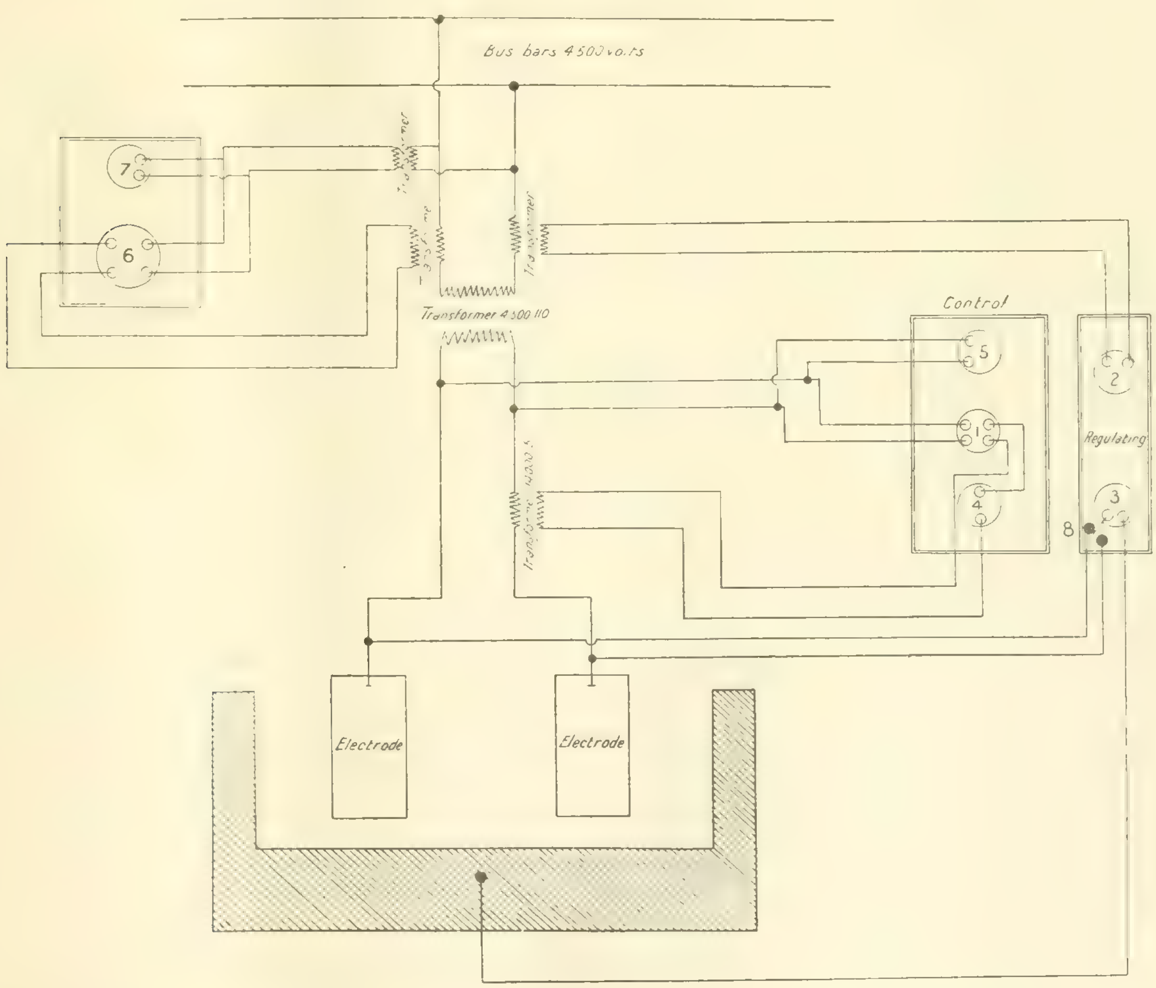
	Lot 1.	*Lot 2.*
	%	%
CuO	10·94 (=8·75Cu)	12·10 (=9·66Cu)
SiO_2	63·58	62·50
Al_2O_3	2·42	3·51
CaO	1·81	0·60
Fe_2O_3	13·28	12·76
MnO	0·51	0·73
MgO	1·05	1·80
S	0·28	0·31
Loss on ignition	5·70	5·40

2. Charcoal.

	%
Fixed carbon	88·35
Volatile matter	5·55
Water	3·92
Ash	2·18

3. Lime.

	%
CaO	91·41
MgO	0·02
SiO_2	0·60
Fe_2O_3 and Al_2O_3	0·24
Loss on ignition	8·17



DIAGRAMMATIC SKETCH OF FURNACE AND ELECTRIC CONNECTIONS.

1 Wattmeter B.T., 1,000 kw.; on the secondary.
2 Ammeter H.T., 0-500 A; on the primary.
3 Voltmeter B.T., 0-70; tension between one electrode and sole.
4 Ammeter, 0-14,000; on the secondary.
5 Voltmeter, 0-150; total tension between electrodes.
6 Wattmeter H.T., 1,000 kw.; office.
7 Voltmeter, 4,500 volts; office.
8 Two-way Switch.

Table I.—Schedule of Weights.

Ore Mixture	Ore Charge						
	Weight		Totals		Per Centage		Composition
	Mixture Kilos	Ore Kilos	Lime Kilos	Charcoal Kilos	Ore %	Lime %	Charcoal %
A	9,165	6,000	3,060	105	65·5	33·5	1·00
B	13,802	9,105	4,540	157	66·5	32·5	1·00
C	4,597	3,075	1,470	52	67·2	31·8	1·00
Totals...	27,564	18,180	9,070	314			
E	15,197	9,700	5,327	170	63·80	35·10	1·1
F	4,197	2,746	1,403	48	65·50	33·40	1·1
G	20,458	13,400	6,847	211	65·55	33 43	1·03
H	12,220	8,170	3,920	130	66·84	32·10	1·06
I	7,830	5,000	2,751	79	63·90	35·10	1·00
J*	10,580	5,000	5,500	80	47·3	52·00	0·70
Totals...	70,482	44,016	25,748	718			

* For lime and charcoal read limestone and coke.

filings; the current passed through, making circuits by contacts or arcs. Immediately the metal had reached the fluid state, the necessary material to form a slag on its surface was added. During this period of formation the current was subject to violent fluctuations. When the slag was formed, the electrodes were placed in contact with it, and the energy of the current largely absorbed by its resistance. Conditions then becoming normal, the charging of the ore mixture began. The furnace was under constant observation throughout the whole campaign, and all materials fed into it were carefully weighed and sampled, as also the slag and metal produced. After tapping, occurrences of blowing out of the material happened, caused by the sudden fall of cool material around the electrodes into the hot zone of the furnace. This blowing out was much more marked when dealing with the limestone mixture, owing to the escape of more gas than under the lime charge.

In the first run there were three different mixtures, and in the second six. Full details as to these and furnace capacities will be found in the schedule of weights, Table I. The second trial lasted five days.

Slags.—The assays of the slags as given for the different mixtures represent "cut-outs," and were taken as representative of those produced by the different ore charges. The higher alumina in the first series was due to the greater fluxing of the furnace lining. The slags produced were very clean and flowed freely, and in the majority of cases readily solidified without passing through an intermediate state of plasticity. The average running temperature was about 1,450°C, this being determined by means of a Wanner pyrometer.

The number of slag tappings in the first series was 25, and in the second 72. The amount of slag produced per ton of ore was respectively 1·22 and 1·24 tons, and averaged 0·25% and 0·3% copper. The metallic contents of the slags compare favourably with those of slags produced in matte smelting, and show a considerable improvement over those produced by direct reduction of this class of ore in blast-furnaces, which might be anything between 1 and 1·5%. Though here it might be mentioned, en passant, that to keep slags low in copper in direct reduction to metal in blast-furnaces, it is advisable, in fact imperative, to have some sulphur present in the charge. The SiO_2 varied from 49%–57%, and represented the bi-silicate type, having the formula R_2O_3, 3 SiO_2, RO, SiO_2, or R_2O_3, RO, Si_4O_8. Prima facie the slags would appear economically and metallurgically good, as they used the minimum of flux, and were low in copper contents, and while they were all right from that point of view, the grade of metal was all wrong; though it will be here mentioned that previous experimental trials on the ore had indicated the possibility of producing high-grade metal with the type of slags as shown in the analysis schedule. How this was accomplished will be indicated under the heading "Metal."

The slag is the primary concern of the smelter, and given the proper one the metal will take care of itself. With a suitable slag there is no difficulty in producing good black copper in the electric furnace, and it is being done. The essential is a fluid slag of low

TABLE II.—ASSAYS AND POWER

Ore Mixture	SLAGS: Analyses: SiO_2 %	Al_2O_3 %	CaO %	FeO %	MnO %	MgO %	CuO %	S %	Temperature Degrees Centigrade	Power Consumption: Per 1,000 kilos ore-charge K.W.H.	Per 1,000 kilos ore K.W.H.
A	54·96	7·35	32·80	3·56	—	0·42	0·20	0·05	1,400—1,460	510	755
B	54·20	8·70	34·12	2·61	—	0·27	0·42	0·04	1,400—1,580	755	1,145
C	53·32	7·21	34·30	4·62	—	0·87	0·22	0·07	1,460—1,540	1,100	1,640
Average Slag	55·01	7·9	33·26	3·57		0·38	0·31	0·057			
E	52·16	4·28	36·81	5·93	0·37	0·81	0·46	0·091	1,400—1,550	696	1,088
F	53·10	3·83	36·41	5·68	0·40	1·17	0·32	0·07	1,460—1,540	597	910
G	53·40	4·06	36·48	5·01	0·38	0·27	0·59	0·08	1,480—1,540	625	955
H	56·70	4·88	34·76	3·08	0·40	0·44	0·51	0·044	1,460 - 1,560	664	992
I	55·18	4·71	35·86	3·64	0·40	0·35	0·26	0·054	1,450—1,540	710	1,113
J*	49·44	3·91	40·58	5·90	0·40	1·24	0·53	0·029	1,400—1,540	600	1,265
Average Slag	52·20	4·97	36·64	5·00		1·17	0·38	0·11			

* For lime and charcoal read limestone and coke.

TABLE III.—SUMMARY OF RESULTS. LONG TONS.

Trial Number	Material Smelted in Furnace: Totals During Trial: Ore Mixture. Tons.	Ore. Tons.	Average per 24 Hours: Ore Mixture. Tons.	Ore. Tons.	Materials Used per Ton of Ore: Lime. Tons.	Charcoal. Tons.	Power Consumption: Per ton ore. K.W.H.	Per Ton of Copper K.W.H.	Electrode Consumption: Per ton of Ore. Kilos.	Per ton of Copper Kilos.	Copper: Recover'd as Metal. %	In Slag. %	Unaccounted for %
1	27·12	17·9	14·95	9·84	0·499	0·017	1,122	14,025	12·40	155·00	91·48	5·0	3·52
2	69·38	43·4	15·15	9·52	*0·519	0·016	1,028	11,719	5·53	63·04	91·10	5·6	3·74
	96·50	61·3											

* Lot J left out.

melting point. The question to consider is not whether the proper ratio between base and acid exists, but whether the bases are of such a nature that the slag will melt at a suitable temperature. This belongs to a study of slags. Iron is readily reduced from its oxides, and it requires much care even at the temperature of the ordinary blast-furnace for smelting copper ores to prevent its reduction. A resistance furnace when operating adjusts itself to the charge, so that with a refractory slag it gets hotter; this increase in temperature results in accelerating the reaction between the somewhat costly electrodes and the iron oxide of the gangue and reduces iron which enters the copper. The power consumption and the general operation of the furnace are all largely affected by the melting point of the slag, and the temperature necessary to make it liquid enough to flow readily from the furnace. The lower the temperature the more rapid the rate of smelting, and the higher the purity of the metal, and consequently the slag best adapted to furnace work is one that gives the greatest furnace output of ore, marketable brand of copper, or suitable matte, compatible with economic conditions.

Bi and tri-silicates form at a temperature 80° lower than mono-silicates, but these acid silicates are not melted at the formation temperature, whereas the mono and sesqui-silicates are quite fluid. Complete fusion of ferro-calcic silicates is difficult to obtain, when CaO greatly exceeds the FeO, and in this case it is advisable to make slags carrying less than 40% SiO_2. In high SiO_2 slags, the CaO should not exceed the FeO. The specific gravity of the slag has also to be considered. CaO lowers it, thus permitting easier settling of the metal. A bi-silicate slag which has CaO to all intents and purposes the only base, the other bases being so small as to be negligible, is fatal in producing a high-grade metal. It is the same with matte production in the electric furnace. Any attempt to make difficultly fusible slags is attended by a decrease in general economy and matte value.

The following data (Table V) will give some indication of typical good slags produced in the electric furnace. The first is that obtained on a commercial scale in treating a highly silicious carbonate ore using ironstone and a small percentage of limestone as a flux. The metal produced averaged 98% copper. The others represent experimental work on native copper material, and gave metal containing 96·24%, 97·96%, and 98·59% copper respectively.

TABLE V.—TYPICAL GOOD SLAGS.

	1	2	3	4
	%	%	%	%
SiO_2	46·2	53·14	51·10	44·88
FeO	35·5	11·58	25·50	29·80
CaO	13·4	12·24	8·78	6·92
MgO	—	3·12	2·03	2·32
Al_2O_3	4·2	20·33	10·45	15·34
Cu	0·35	0·31	0·23	0·15

METAL.—In the first trial as previously mentioned no metal was tapped, and the fused mass of copper and brick lining removed from the furnace could not be weighed or properly sampled. The metal recovered has been based on the average slag assay, and due allowance has been made for other losses as indicated by the second trial. In the second campaign only 3 tappings were obtained, the first 9 hours after starting, the second 20 hours, and the third 31 hours, giving altogether 400 lb. of metal product. Copper with a high percentage of iron chills quickly, and the formation of crusts of slag or other material in proximity of the tap-hole may in some measure account for the inability to tap more metal. The formation of such crusts in treating an ore charge in an electric furnace is of common occurrence, and can be overcome by adding to the furnace at intervals just previous to tapping and in line with the tap-hole easily fusible material such as CaF_2 or old slag.

The analyses of the three metal tappings were as follow :

	1	2	3
	%	%	%
Copper	75·96	61·25	57·74
Iron	23·60	34·75	39·90

Toward the end of the smelting this metal was thrown back into the furnace and remelted with that remaining in the furnace.

After all the ore mixture had been smelted and the slag tapped, the contained metal was run from the furnace by boring a tap-hole lower down and the metal run to specially constructed moulds, in order to segregate the metal into a high and low grade product. Segregation does take place under certain limits, but as to what these are exactly has not been so far determined.

The following segregated metal was obtained: 2,275 kilos assaying 91% copper and 8·03% iron, with traces of silicon; and 3,535 kilos assaying 51·01% copper and 45·72% iron, with traces of silicon; total 5,810 kilos assaying 66·68% copper and 30·96% iron; the iron equals 45·71% of total present in the ore. In lot 1, the product averaged 57·60% copper and 40·20% iron, and contained 63·4% of the iron in the ore.

The 2,275 kilos of metal represent 39·16% of the total produced, and 48·7% of the total copper in the ore. The 3,535 kilos represent 60·84% of the total produced, and 42·4% of the copper in the ore.

In Messrs. Keller's experimental trials the products of segregation were represented by metal of the following grades: No. 1 Product, copper 93·84%, iron 5·34%, Si 0·699%, and represented 88% of the total copper; No. 2 Product, copper 16·51%, iron 79·0%, Si 3·58%, and represented 6% of the total copper of the ore. In the earlier runs the following represented the ratio type of ore mixture: 1,000 kilos ore, CaO 400 kilos, bauxite 80 kilos, fluor-spar 30 kilos, charcoal 17·5 kilos.

ELECTRODES.—The actual consumption recorded in Table III. was obtained by measurement. To allow for losses by breakages and portions of electrodes that could not be utilized in actual practice, 20% should be added to compute works practice. The electrodes employed were suitably coated to prevent undue oxidation, and were water-cooled, thus preventing the burning of the electrode and heat getting to the transformer. Twenty litres of water passed through each electrode per hour and a rise in temperature of 8°C. was shown. The water became electrically charged. A new set of electrodes was employed for the second trial.

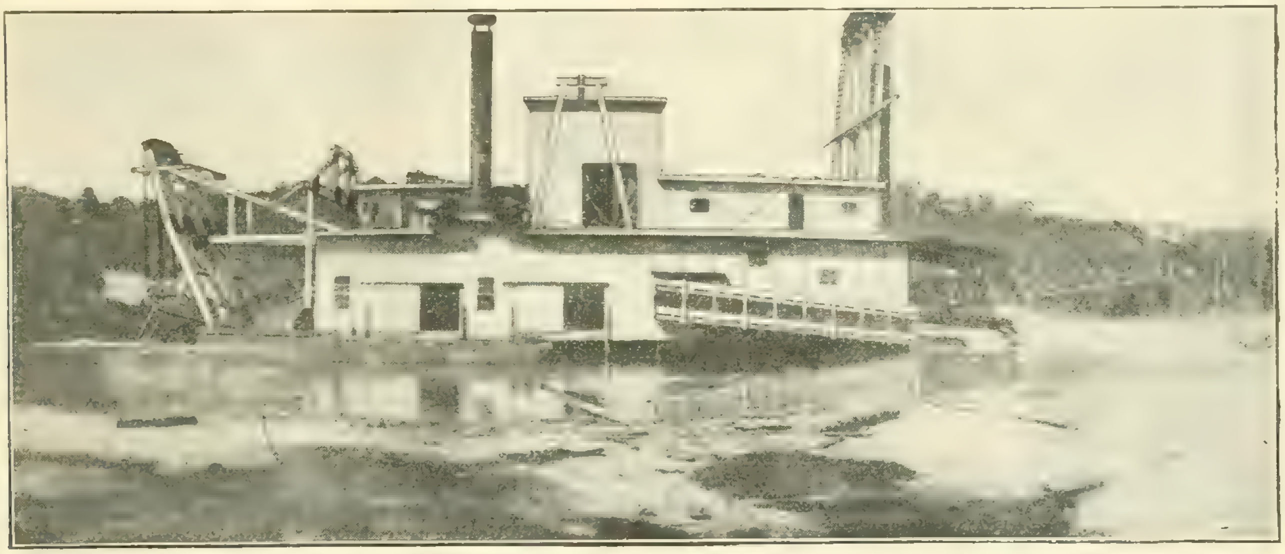
POWER CONSUMPTION.—The current employed for preliminary heating has not been reckoned in the figures recorded. The current used was one of low voltage and fairly high amperage. In No. 1 test the volts varied from 96 to 106 and the amperes from 2,400 to 5,500; in No. 2, the volts varied from 96 to 104, and the amperes from 3,500 to 6,000. The average consumption of energy during the stable periods of the trials (mixtures F and G) was 955 kilowatt-hours per ton of ore, and the consumption per ton of copper was in trial 1, 1·6 kilowatt-year, and trial 2, 1·34 kilowatt-year.

THREE BIG AMERICAN GOLD-DREDGES.

Details are given of the design of three gold-dredges ; one working the Mambuloa gold gravels on the sea-shore near Paracale, in the Philippine Islands ; another now under construction for the goldfields of the Lena ; and a third being built for the operation of Government lands in Nerchinsk, Eastern Siberia.

THE PHILIPPINE DREDGE.

In the issue of the Magazine for August 1915, Mr. Charles Janin gave some information relating to dredges operating in the Philippine Islands, or under design and construction for work in those islands. He mentioned the dredge that was being designed by the New York Engineering Company for the Mambuloa Placer Co. of Paracale, in the island of Luzon, and he gave an outline of the details of its construction. This dredge went into operation in July 1916, and, though it contained several novel features, its performance was satisfactory from the start.



THE MAMBULOA DREDGE.

The placer ground which it is treating extends into the bay of Mambuloa, and in this respect resembles the Tongkah Harbour Company's property. This bay is subject to severe storms and typhoons. During construction work, one of these typhoons occurred, carrying houses to a considerable distance, and doing much other damage. The erection of the dredge was not interfered with, as provision had been made against storms of this character.

This dredge is driven by a turbo-electric generating plant, placed on the dredge, and supplying electric power for the motors which drive each separate unit. A clay sluice has been introduced. This is placed directly over the screen on the top of the dredge running aft to the stern, where it divides into two branches, each branch extending over and beyond the stern about 35 ft. This sluice is intended for the purpose of by-passing the large amount of barren overburden, which is about 45 ft. deep and consists of sand, clay, and soil. The auriferous gravel lies underneath this, and is from 5 to 10 ft. thick. When the buckets come to the gravel, a hinged gate at the top of the sluice is opened, and the gravel is thus dumped direct into the screen chute.

The steam-electric plant consists of a 625 K.V.A. steam turbine, direct connected to an alternator working at 440 volts. A water-tube boiler is arranged for burning wood fuel, and has straight tubes with header openings at each end to facilitate cleaning. The boiler furnishes steam at 156 pounds pressure, and the steam turbine runs condensing, having a vertical type of condenser with 1 in. brass tubes. The condenser is cooled by the water from the large centrifugal pump, as it passes on the way to the gravel-washing screen. The vertical type of condenser, with the large tubes, prevents the deposit of sediment and sand which this water carries, owing to the fact that the wash water must be taken from the dredging pond.

A separate electric motor is provided for driving each of the units of the dredge, the total of these motors aggregating 450 h.p. This arrangement of the steam plant has secured a great economy in fuel consumption, as the dredge requires only fourteen cords of wood per day at full load. It is estimated that if the dredge had been equipped with the usual type of individual steam engine for each separate unit, the fuel consumption would have been approximately double this amount. This estimate is based on the calculation of other steam-driven dredges operating in the Philippines.

The placing of a number of steam engines in different parts of the dredge, to drive the different units, has always been a most objectionable feature, as each engine requires individual attention. Such engines are not readily operated and reversed from the pilot house, whereas the alternating current motors practically require no attention, and are readily started or reversed from any place, as many of the large and important motors have electrical control apparatus placed at different points of the dredge, from which they may be instantly stopped in case of sudden accident. The steam electrical plant also does away with a large quantity of small steam piping, which is required when there are numerous small engines in different parts of the dredge. It is difficult to keep all of this small piping tight, and it is also difficult to maintain a suitable vacuum in the condenser where so many small pipes return from the engines to the condenser.

The dredge digs 55 ft. below water line, and stacks 35 ft. above water line. The hull is 136 ft. long, 10 ft. deep, and has a beam of 47 ft., with an overhang of 3 ft. on each side. The hull is of wood, and as it operates in salt water, a ship sheathing-felt is placed outside the regular 4 in. planking, and this in turn is covered with 1½ in. native planking. This felt is a hair felt, which has been dipped in preserving material, and then rolled into flat sheets about ⅛ in. thick. It is sufficient to prevent injury by boring mollusca. The wood hull was decided upon because it was cheaper, and the steel hull when working in salt water would require frequent docking and painting, which is impractical in this particular case. The ventilation of a wood hull in the tropics is the most important point, and this was very well taken care of in the present installation, by the fact that the steam turbo-generator required a large amount of air for cooling the armature. This air is taken directly from the hull and then passed through the armature; thus it causes a complete change of air throughout the entire hull every ten minutes.

Provision had to be made in this dredge for taking care of the rise and fall of the dredge on the digging spuds, due to the operations of the tide. This involved the paying out of the spud lines and taking care of the slack automatically. This was accomplished by having the sheave blocks at the upper end of the spud mounted in a sliding frame so that they had a vertical movement within the spud of about 6 ft. This takes care of the slack in the spud line as the tide falls. Another feature of interest is an equalizing sheave, which is placed on the top of the main gantry for the ladder-hoist ropes. The ladder-hoist rigging consists of two sets of lines, one on each side of the ladder. One end of each line runs to the double drum of the ladder-hoist; the other two ends of the line join and operate over this equalizing sheave at the head of the main gantry. This takes care of any undue stretch in either set of ropes and equalizes the strain on both sides of the ladder. A similar arrangement was also applied to the hanging of the long stacker, which, instead of being supported at two points, is suspended from three points, the supporting rope being reaved through equalizing blocks at the three points.

The buckets each consist of a one-piece manganese steel casting, the lip and hood being cast integral with the back, thus doing away with all rivets in the bucket. The lip is so proportioned as to last as long as any other part of the bucket. This type of bucket was adopted on account of the easy digging of the ground in question, but it should not be assumed that this design is suitable for all conditions of ground. The bucket has come up to expectations, and the wear appears to be equal on all parts. This doing away with all rivets in the bucket saves a large amount of time and repairs.

The dredge is equipped with a nine-drum winch, leaving two spare drums for extra requirements. The revolving screen is 40 ft. long and 6 ft. 6 in. in diameter, with tyres having 12 in. face. It is supported on a cast steel trunnion ring at each end, and it is driven by one driving roller placed under the centre of the lower ring, while two small side idler rollers, placed on each side of the ring, hold the screen in place. The manganese steel thrust rollers on each side take the longitudinal thrust of the screen.

A second dredge will probably be installed at a later date, and then the steam electric generating plant will be taken off the present dredge, and placed on shore. The removed plant, together with another power unit, will then furnish current for both dredges. The placing of the power plant on board the dredge when only one dredge is in operation offers many advantages, but when two or more dredges are at work, a central power station for them all, built on shore, is more efficient and convenient.

The dredge cost £60,000, but as the gravel is rich, the capital outlay should soon be recouped. We hope at a later date to give details of the property and the results obtained.

The Lenskoie Dredge.

As has already been mentioned, the Lenskoie Gold Mining Co., the Russian company until recently controlled by the Lena Goldfields Limited, has placed an order with the Bucyrus company for a big dredge of California design with buckets of 17 cubic feet capacity. The designs are not yet far enough advanced to warrant the publication of a full illustrated description of the dredge at this time, but a large amount of information is available, and in view of the great interest shown in this new departure, we give these details herewith.

The dredge will have a steel hull about 170 ft. long, 60 ft. beam, and 14 ft. deep. Among the leading features of this hull, interesting in comparison with previous designs, are a somewhat novel system of main fore-and-aft trusses, and also the design for the between-decks trussing, which tends to a lighter and more rigid construction. The main trusses are placed wider apart than has been usual in dredge practice, and extend in straight lines from stem to stern. Each fore-and-aft truss is placed over a complete between-decks bulkhead, which constitutes the lower chord of the truss and also serves as a watertight bulkhead. The latticed truss structure is entirely above deck, except where some of the diagonal members are carried through the deck to get adequate attachment to the bulkheads. The upper chords of the trusses are horizontal throughout their length, ending at the stern in the attachments for the upper spud keepers, the spuds being placed exactly in line with the trusses in order to land in the best possible manner the heavy spud reactions against the structure best adapted to resist them. Special attention is paid to extra heavy abutments on the floor of the dredge at the stern to take the kick of the spuds, and including careful design for portability and the least possible field riveting. A minor feature of interest is the design of truss diagonals in such a way as to provide an opening wide enough for the gold-saving tables without passing truss diagonals through the tables. Another interesting point is that all of the diagonal members of these trusses have been made of adjustable bridge eye bars instead of the usual riveted construction. This is done at the instance of the Lenskoie Company to reduce the work of field erection under the difficult circumstances existing in this region.

The loads both of water pressure from below and machinery, etc., from above are transmitted to the main trusses by a system of transverse trusses and bulkheads, which cannot be described in detail at this time. The underlying idea, however, is illustrated by the action of the principal cross bulkhead under the main posts of the upper tumbler and just aft of the well. As this bulkhead is 14 ft. deep, it is of ample strength to carry the upper tumbler, resting on its posts 10 ft. apart, and to transmit this load to the trusses, which are 20 ft. apart, without causing any considerable strain on the bulkhead. On the other hand, the two ends of this cross bulkhead between the trusses and the sides of the hull are easily able to carry the great flotation load which is transmitted to them by the sides, and land these upward reactions in the trusses. These upward flotation reactions have constituted the principal difficulty in keeping hulls from sagging in the middle, and the advantage of wide spacing of the trusses is evident.

A system of overhead cranes is provided for handling the upper tumbler, gears, the parts of the winches, etc. In designing these cranes it has been sought to provide everything necessary for prompt repair, without going to the extreme in providing more than is justified by actual use. Two jib cranes are provided at the bow, one at each side, for handling the buckets, etc. These will be power-operated, and small winches will be provided at bow and stern for passing light lines ashore to handle shore sheaves, deadmen, etc.

The buckets are of manganese steel, of heavy construction, the pitch being 42½ in., with 8 in. pins, and lips 2½ in. thick. The bottom is cast in one piece with the hood. The depth of digging is 80 ft.

The bow gantry is inclined farther forward than usual, making a more equal division of load between the connecting links of the two-part ladder suspension than in previous dredges. The ladder hoist tackle at the bow gantry cap is greatly simplified by mounting all of the sheaves on pins through lugs cast integral with the bow gantry cap castings. This avoids all shackles and suspension bars, which have previously been used on bow gantry caps. The back braces from the truss to the bow gantry cap are of structural steel, pin-connected to the truss and cap.

The screen drive is of new design, using only spur gears to drive the single supporting roller under the after end of the screen. Driving connection from the motor is made by silent chain. The upper ladder end bearings are concentric with the tumbler shaft, the latter ends landing directly on the upper tumbler shaft bearings. The upper tumbler shaft is supported on two main posts about 10 ft. between centres, which rest directly on a transverse between-decks bulkhead, which is 14 ft. deep. This bulkhead transfers the tumbler leads to the main trusses, which are about 20 ft. apart, as previously explained. The wide spacing of the trusses greatly assists in distributing the various loads over the flotation, while the heavy machinery loads are easily landed on the main trusses in the manner described.

The main winch is provided with two wide-faced bow swing drums capable of winding 2,400 ft. of cable, to permit the dredge to breast across a 1,200 ft. face when necessary. The principal new feature of this winch consists in the omission of intermediate bearings previously used, and making the drum shafts 7½ in. diameter. This avoids having three bearings on these short winch shafts, such bearings being extremely difficult to line-up perfectly, and frequently tending to break the shaft rather than to support it. The upper tumbler drive will be provided with a new type of equalizer, and the first gear reductions will be of cut herringbone type. The upper tumbler gears will also have cut teeth. The ladder rollers are of high-carbon steel with journals cast integral with the rollers and provided with renewable shells. There are two banks of gold-saving tables, receiving the material through an improved and simplified type of distributor. The tailing stacker will be completely enclosed, for heating purposes, and a very large and complete heating plant will be provided to heat the entire dredge.

The dredge will be operated from a 3 phase, 50 cycle, 5,000 volt supply, transformed on the dredge to 500 volts. The main drive motor will be 500 h.p., and the other motors in proportion. The main drive motor is provided with automatic time-limit control, and the other variable speed motors with drum controllers.

The water for the screen and tables is supplied by two 16 in. pumps, each delivering 6,250 gallons of water per minute, together with a 6 in. two-stage pump with a capacity of 1,000 gallons of water for the hopper and other high pressure service. A 12 in. monitor pump is also supplied. This will be used to wash down high gravel banks in front of the dredge. On the property where this dredge will operate, there are a number of old tailing dumps from underground workings which, it has been found from experience in the Lena district, remain frozen throughout the summer. By using the monitor the face can be washed and the frozen surface exposed to the sun, and thawing will thus keep pace with the progress of the dredge.

The working season will be about 200 days and the conditions which the dredge will meet when operating are similar to those to be found in Alaska. In some places a working face of 20 ft. above the water level will be carried. The gravel is sub-angular with few large boulders that cannot be handled by a dredge of this capacity, and the bedrock does not present any difficulties to successful operation.

Transportation of this dredge is quite an undertaking. Shipment will be made from San Francisco or other Pacific Coast port to Vladivostok, thence by rail to Irkutsk, Siberia. From this point it will be moved a distance of 170 miles to Kachugie on the Lena River during the winter season by means of sleighs, and from there it will be transported by shallow-draft barges a distance of 1,025 miles down the Lena River to Vitim, then up the Vitim River to Bodaibo. Here the Lenskoie Company has arranged for large derricks to unload the machinery direct from the barge to cars on the siding of a narrow-gauge railway that leads to the property about 15 miles distant.

The Lenskoie Company has large machine shops at Bodaibo for maintaining the railway equipment, which will enable them to make all the necessary repairs for the dredge.

The Novotroisk Dredge.

A gold-dredge is now under construction by the Bucyrus Company to work on the alluvial deposits belonging to the Imperial Cabinet at Novotroisk on the Unda River, in the Nerchinsk district of Eastern Siberia. This dredge is designed to dig to a depth of 26 ft. below the level of the water with the digging ladder at an angle of 45°. The hull is of steel, 115 ft. long, 60 ft. beam, and 9 ft. deep, and is being stiffened by two longitudinal water-tight bulkheads which extend the full length of the dredge. There will be three transverse bulkheads between decks, one of which will be at the centre of the dredge directly under the upper tumbler, one about midway between the centre bulkhead and the bow, and the other near the stern. The longitudinal above-deck trusses are directly over the water-tight bulkheads, which will act as the lower chords of these trusses.

The buckets, which have a capacity of 7½ cu. ft., are high-carbon steel castings of heavy construction, about 30 in. pitch, and made in one piece with a renewable manganese-steel lip.

The bucket pin is a high-carbon steel forging. The lower tumbler will be a single manganese-steel casting with circular tread and flanges.

The revolving screen on this dredge will be about 6 ft. in diameter and about 35 ft. long overall, and driven from the lower end by a single high-carbon steel roller mounted directly below the lower screen tyre. The upper end of the screen will be supported by two high-carbon steel rollers and will be held in position transversely at the lower end by two idler rollers. The thrust due to the inclination of the screen will be taken care of by a single roller acting against the face of the lower screen tyre.

The dredge when operating will be held up to the working face by means of structural steel spuds 24 in. by 36 in. by 48 ft. long, having annealed steel casting points on the lower ends. For hoisting the digging ladder and driving the bucket line there will be one 150 h.p. tandem compound link reversing engine, and a 250 h.p. vertical compound engine for driving the pumps and other machinery.

Water for washing the material will be delivered on the gold-saving tables by one 8 in. centrifugal pump having a capacity of 2,000 gallons per minute, and one 10 in. pump for supplying the water to the screen having a capacity of 3,000 gallons per minute. A 5 in. pump capable of delivering 1,000 gallons per minute against a head of 100 ft. will deliver water into the hopper.

For easy handling of repairs the dredge will be equipped with a 1½ ton jib crane mounted near the bow, and will have a 10 ton travelling crane mounted over the upper tumbler and so arranged that parts may be picked up directly from the bank. The digging ladder will be of plate girder type about 74 ft. in length and suspended at the upper end concentrically with the tumbler shaft.

The property where this dredge is going to work is favourably suited for dredging purposes, free from clay and frozen ground, and the operating season will be about 145 days. The dredge will be shipped from the Pacific Coast to Vladivostok and transported thence by rail to Preeskovia, a point on the Trans-Siberian Railway. It will then be taken by sleighs over the ice in the winter season to the mine, which is situated at a distance of about 18 miles from the railway.

THE HYBINETTE NICKEL PROCESS.

THE Ontario Nickel Commission's report describes the Hybinette nickel refining process, which is to be used by the British American Nickel Corporation at the Murray mine, Sudbury. The copper-nickel matte, containing about 47% nickel, 33% copper, and 20% sulphur, with usually less than 0·4% iron, is granulated and roasted. It is then leached with a 10% solution of sulphuric acid to dissolve the greater part of the copper. The residue is melted and cast into anodes. The electrolyte used carries 45 grammes of nickel and from 3 to 5 milligrammes of copper per litre, and is supplied by rubber tubes to the cathode diaphragms. After circulation it has from 2 to 3 gm. of copper per litre, and is passed over waste anodes which deposit the copper and re-supply nickel to the solution. The action of the anodes is analogous to that of pig-iron in precipitating cement-copper, except that the copper is deposited by nickel instead of by iron. The solutions never have to be rejected, as they are sufficiently purified by the cementation. Waste fragments, after the cement-copper has been brushed off, are crushed, roasted, leached with 10% sulphuric acid to dissolve more copper, and the residues are melted into anodes and re-electrolysed. The anodes for the nickel department are enclosed in special canvas bags, stated to last 18 months. Paper diaphragms supported by common canvas at times have been substituted and have lasted 12 months. The cathodes are of iron treated with a wash of powdered graphite. The nickel is deposited on both sides of the cathode plate. These plates are arranged in parallel. The voltage is from 3 to 4 volts per vat, according to current density, which varies from 8 to 10 amperes per square foot. The deposition of the nickel takes about 15 days, and the sheets stripped from the cathodes weigh 20 to 30 lb. each. They are about ⅛ in. thick, and have the usual corrugated warty appearance, but the stalactitic growths are dense and give no trouble through short-circuiting. The sheets are washed in weak sulphuric acid to remove basic salts, are dried, and cut into 2 by 3 in. strips for market. The metal is guaranteed 99% pure, with usually no more than 0·03% copper. The precious metals accumulate in the anode slime, which is re-melted into anodes and separately electrolysed, the final slime being caked, dried, and sold for its precious-metal content. This process is carried out in Norway on matte from Evje and Ringerike, where power costs about $13·50 per horse-power-year. The ore treated averages 1·6% nickel and 0·9% copper. The copper produced averages 99·72 fine.

ORE TREATMENT AT THE PERSEVERANCE MINE,

KALGOORLIE, WEST AUSTRALIA.

By the late W. R. CLOUTMAN, A.R.S.M.

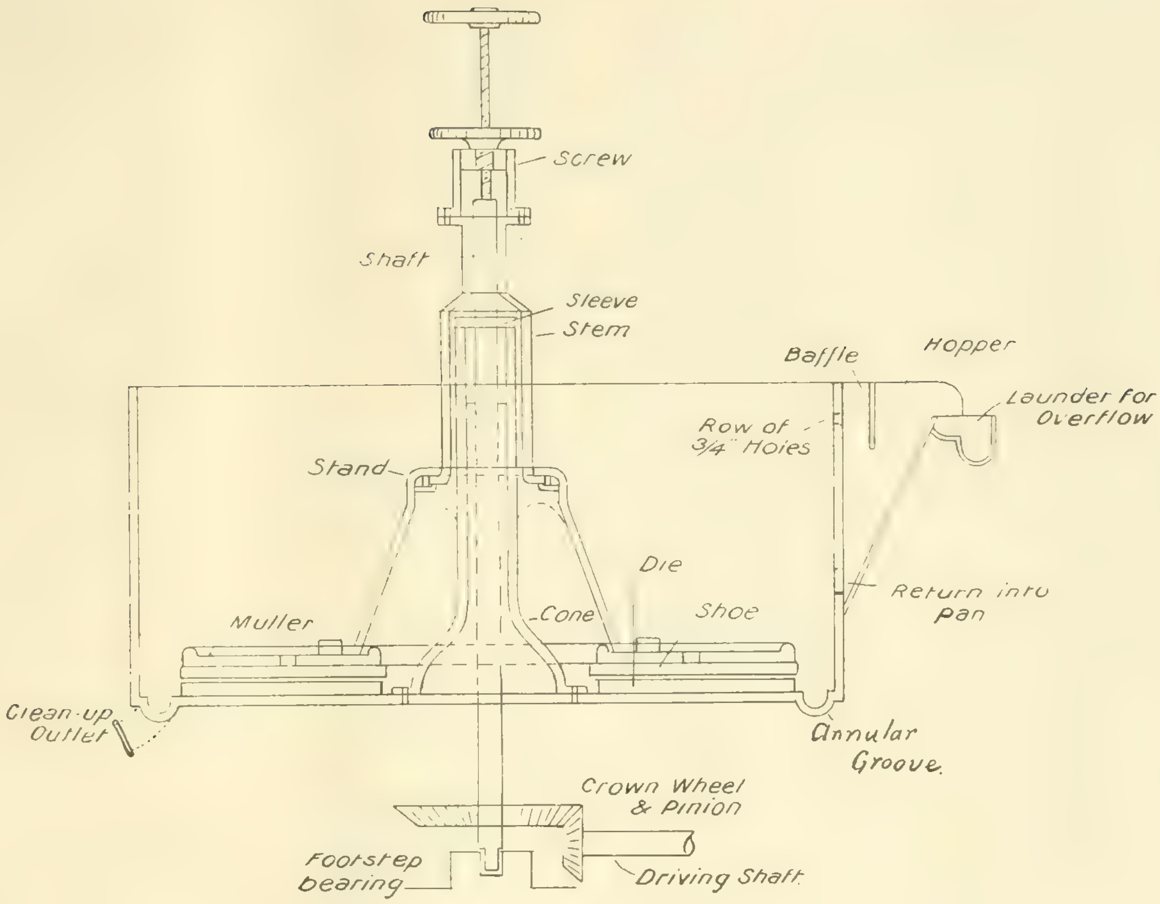
(Continued from the May issue, page 244).

The third section of this article gives details of the Wheeler pans and tube-mills, and describes the agitator-vat practice.

WHEELER PANS AND TUBE-MILLS.—The ore discharged from the cooling hearths of the roasters is taken by a push conveyor to a chain bucket-elevator, which elevates the ore to the mixer. In case of breakdown of the elevator, there is a spare one at its side. The height of the elevators is 64½ ft., and each has 86 buckets, having dimensions 12 by 6 by 5 inches. In the mixer, the ore is mixed with the dilute cyanide solution from the head storage tanks. The mixer is of the vortex type, with 4 propeller shaped vanes rotating at 260 r.p.m. The size of the mixer is 4 ft. 6 in. diameter by 3 ft. 8 in. deep. Owing to the shallow depth of the mixer, the coarse sand is unable to settle, and is swept out into the launders. The rotating shaft is driven by a crown-wheel and pinion. At the point where the pulp is discharged from the mixer, lead acetate solution is added, coming as a drip from a small storage tank set near the mixer. The cyanide solution fed to the mixer comes from the head storage tanks at the top of the building through 4 in. pipes, and can be taken from either or both tanks. This solution carries about 0·028% free cyanide, being zinc-box tails pumped up to the tanks.

The fine grinding is done by Wheeler pans and tube-mills, the distribution of the pulp being as follows: one third goes to Number 1 section of 5 pans, one third to the two tube-mills, whose discharge is returned to No. 2 section of 7 pans, and one third to No. 3 section of 5 pans. From the mixer, the pulp passes to two launders, one of which takes one third of the total direct to No. 3 pan section. The other two thirds goes to a spitzkasten 5 ft. square, and inverted pyramid shape, 5 ft. 8 in. deep. This has a baffle-plate projecting a few inches below the surface of the solution, so that the contents are not violently disturbed by the entering current. The overflow is at one side and, consisting of slime, is allowed to run direct into the agitation vats. The underflow goes through a 1½ in. spigot and passes to the launder feeding No. 1 pan section and the tube-mills. The product from the ball-mills is coarser than that produced by the old battery of Griffin mills, and only 50% will pass a 150-mesh screen; consequently this sand needs more water and a larger spigot than did the Griffin mill pulp. Of the pulp from the Griffin mill 75% passed 150-mesh, and ¾ in. spigots were used. Branches from the launders take the feed to the different pans and the tube-mills. The tube-mills also get the underflow from the small spitzkasten, which separate the product from each of the pans. The pulp from the tube-mills flows to a sump, from which it is pumped up again to the level of the mixer, into another five spitzkasten; the overflow goes direct to the vats, and the underflow to the middle section of the pans.

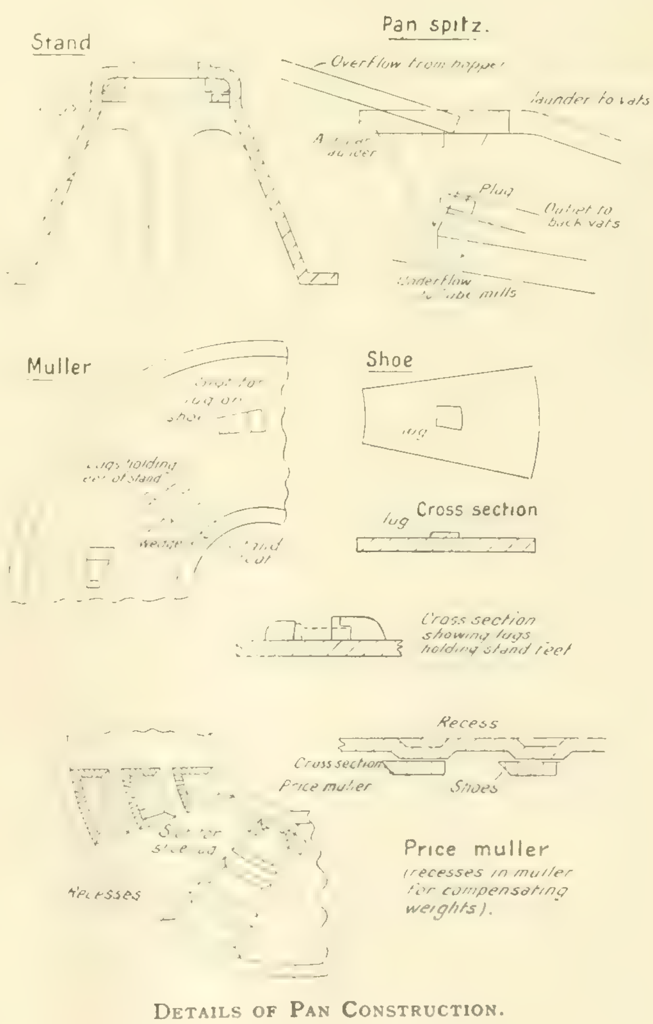
CONSTRUCTION OF WHEELER PANS.—The pans are 8 ft. in diameter, with a cast iron bottom, and steel sides 3½ ft. high. A cone is bolted to the base, and up through it passes the driving shaft, driven by bevel-gearing from below, and resting in a step bearing. At the top of the cone is a sleeve fitting round the driving shaft. The stem carrying the muller is rotated by the shaft, to which it is fastened by gib keys in a feather. A screw is bolted to the top of the stem, and through it passes the setting screw, whose lower end bears on the end of the shaft, and which carries the setting wheel and a locking wheel. The lower end of the stem fits in the top of the stand, and is held in place by lugs, leaving enough play for the stand and muller to find their level on the base of the pan. The four feet of the stand fit into recesses in lugs on the muller. They are held tight against them by wedges between the feet and the lugs on the free side. The muller is 7 ft. 6 in. across, with a 2 ft. diameter opening in the centre. It is of cast iron and about 1 in. thick, and it carries 8 shoes. The shoes have lugs on their upper surfaces, which are driven into slots in the muller. The slots are tapered, so that the lugs on the shoe tend to tighten in their slots when the muller rotates. The space at the larger end of the slots is filled with a wooden wedge, so that if the shoe works loose, it cannot move to the large end of the slot and fall out. The shoes are in the shape of sectors of a circle, and weigh 2 cwt. each. They are approximately 5 in. apart on the inside periphery, and 16 in. on the outside. The twelve dies are of the same size as



VERTICAL SECTION OF GRINDING PAN.

the shoes approximately; they have slots of about 1 in. between them, and the lugs on their under sides fit into recesses cut in the bottom of the pan. These slots have their smaller ends in the opposite direction to those in the muller, so that as the muller moves round, the effect on the dies is to tighten them in their slots. The 1 in. spaces between the dies promote circulation of sand at the bottom of pan. There is a recess round the pan bottom, which facilitates work at the clean-up. Four baffle-plates fixed to the side of the pan direct the flow of the pulp to the centre, and prevent the sand being carried round the pan in the current near the surface.

The shoes and dies should be of grey iron, or hematite iron, and each set should be from the one pour, so that they may wear down evenly. White iron or steel is too hard, and shoes and dies made from them will not grind properly, and after use, instead of being abraded all over the grinding surface, they are smooth and polished. The iron must not, of course, be too soft, if excessive wear is to be avoided. The grinding of pulp done bears a definite relation to the amount of abrasion of shoes and dies. During June 1913 the abrasion of the shoes and dies came to 5·6 oz. per ton of ore treated. The shoes and dies are



DETAILS OF PAN CONSTRUCTION.

both $2\frac{1}{2}$ in. thick when new. The shoes wear $\frac{1}{2}$ in. per month normally, and the dies $\frac{1}{4}$ in. at most. They are taken out when 1 in. thick; hence the life of the shoes is about 3 months, and that of the dies 6 to 9 months.

On the front side of the pan is a small hopper, into which the ground pulp is washed through a series of $\frac{3}{4}$ in. holes in the side of the pan, just below the surface of the contained pulp. A baffle-plate reaching about 3 in. below this level prevents agitation of the liquid in the hopper. There is a hole about 3 by 2 in. in the side of the pan at the bottom of the hopper, and sand settling from the pulp in the hopper is returned through it to the pan. The overflow from this hopper flows into a short launder, leading to the centre of a small spitzkasten, 20 in. in diameter. The overflow from the spitzkasten passes to the agitation vat launder, and the underflow goes to a launder leading to the tube-mill Callows. There is also an outlet in the side of the spitzkasten, normally kept plugged, through which an unseparated pulp can be discharged directly into the back row of vats. The spigots of the outlets are $\frac{3}{8}$ in. diameter.

The pans in section 1 and 3 are run at 29·5 and 30 r.p.m., and those in section 2 at 24·5 r.p.m. A good mean for all-round work with 8 ft. pans is 27 r.p.m.; 5 ft. pans may be run much faster. If sand fed to the pans is free from slime, a higher speed is also permissible. Each pan deals with from 40 to 45 tons per 24 hours. Compensating weights to make up for shoe abrasion, both as rings and as blocks fitting into recesses in the muller, have been tried, but did not prove a success. Each pan is driven from a separate countershaft, itself driven from the main shaft by a belt, with a jockey pulley for tightening purposes. The pans take about 7 h.p. each.

The pulp from the ball-mills contains on an average 50% of material which will pass through 150-mesh, and the residues from filter presses average 70% through 150-mesh, so that the fine grinding by pans and tube-mills accounts for 20% through 150-mesh.

Wheeler pans are good amalgamators, and 40 lb. of mercury is added to each pan on restarting after each monthly clean-up. The clean-up is begun during the third week every month, and no further mercury is added during the month. With rich ore as treated in earlier days, a larger quantity was added, about 100 to 200 lb. per pan. Most of the gold amalgam is found beneath the dies. The amalgam recovered in the pans contains about 20% of the total yield of gold. The loss of mercury is about 0·06 oz. per ton of ore treated, the pans losing a little over 3 lb. each per month.

Notes on Running of Pans.—Once or twice every shift the pans are "set" to take up wear of the shoes and dies, so that the muller shall be "down" and grinding properly. To do this the setting wheel is turned, after loosening the locking wheel, in the direction of rotation of the pan until the screw is off the shaft, and the muller will then be right down. It should not be left in this position, neither should it be swung much off the screw, since any inequalities in the surface of the shoes or dies may cause them to catch on each other with possible damage to the muller, crown wheel, etc. By holding the setting wheel for a moment so that it cannot turn, the stem, and with it the muller, rise on the screw. As a rule, the slack is taken up and the muller allowed to rise the merest fraction of an inch. The locking wheel is then tightened to keep the screw in position. With a new set of shoes and dies, there is excessive agitation, which continues until they are worn down. After being disturbed at clean-up time, a pan takes several hours to settle down and start grinding properly again. If a pan is very light, there is no agitation and no grinding; the sand swirls round the top and does not get down; the pan may also then start rocking, when the muller must be lifted.

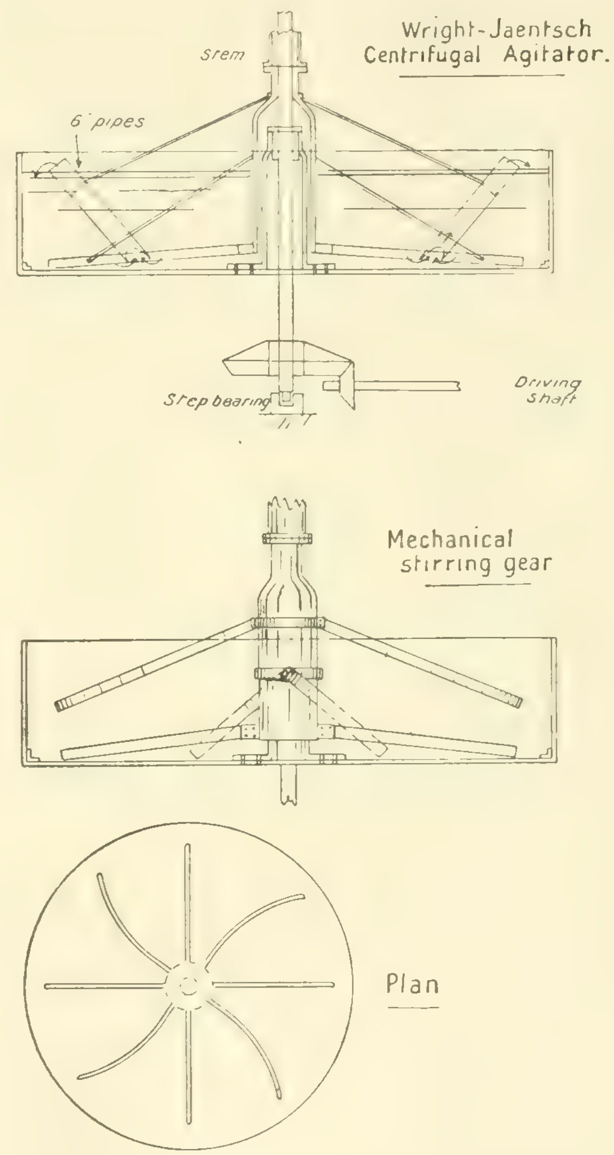
In case of stoppage of the tube-mills, the pans have to take the whole of the pulp. A large portion of the primary feed can be diverted to the middle section of the pans, and care must be taken that the end pans do not get too heavily overfed. Since no underflow can be sent down from the small spitzkasten, the side outlets must be opened, and the pulp sent straight into the back row of agitation vats.

If a pan is overfed and gets heavy, the sand will pile up on the sides of the hopper. If possible, the feed should be cut off entirely, and the pan allowed to grind for about an hour, and water supplied to the pan all the time. After an hour, the pan should no longer be heavy. The sand is then washed out of the pan with a heavy stream of water, and normal feed started again. Unless these precautions are adopted, the heavy load in the pan may cause it to throw off its belt, or give rise to a breakage. In case a pan stops through throwing off its belt, failure of power, etc., it must be started again as soon as possible, since the sand packs, or sets hard, very quickly. In starting such pans, the muller is lifted (most of its load then falling through on to the dies) and turned by hand if possible. If this can be done, it is put on to its belt and started up. Once started, the muller is gradually let down on to the dies. If the muller is lifted, and cannot be turned by pulling on the belt, the sand falling through will get so hard that the only way to get the pan going again is to dig it out. If the pan is left with its muller too high above the dies, no grinding will be done, and the pan in consequence silts up.

TUBE-MILLS.—The two tube-mills receive one third of the primary feed and the underflow from the small spitzkasten in front of each pan. They are each 16 ft. long and 4 ft. in diameter, of Krupp make, running at 30 r.p.m. Each takes 30 h.p., and between them have a capacity of 300 tons per 24 hours, of which quantity 60 tons is slimed. The feed comes to them through 6 ft. Callow cones which have no overflow, the spigot, 1 in. in diameter, taking the pulp into the mill through the hollow trunnion. A couple of propeller shaped vanes lead the feed into the mill. The liners have corrugated surfaces, 6 in. from one ridge to the next. The end plates have smooth liners. At the discharge end is a perforated plate with $\frac{3}{4}$ in. holes. The pulp passes through the trunnion to a launder which takes it to the sump. These mills are both driven through gearing, the pinions being joined to the motor pulleys through flexible couplings. The liners are cemented to the sides, to prevent fine gold lodging behind them. The flints used are $2\frac{1}{2}$ by $1\frac{1}{2}$ in. in No. 1 mill, and $3\frac{1}{2}$ by $2\frac{1}{2}$ in. in No. 2 mill. The load should be 10,000 pounds of balls, and the level in the mill should be kept at 4 in. below the axis of the mill. Flints to the extent of 250 to 400 lb. are added during every fortnight to make up for wear. The flints should not be too hard. When re-lining a mill, all flints under $1\frac{1}{2}$ in. are rejected. The liners in the tube-mills (excluding end plates) had not had to be replaced by the time of writing in 1912, owing to their wearing out, since first put in (August 1910); they are of Krupp steel, $2\frac{3}{4}$ in. thick.

Including flints rejected through being undersize, the weight to be made up in each mill after cleaning out is 10,000 to 15,000 lb. On the whole medium-size flints of about $2\frac{1}{2}$ in. diameter are believed to be the best for the purpose in hand.

AGITATION VATS.—There are 24 agitation vats, each 20 ft. in diameter, by $4\frac{1}{2}$ ft. deep The majority are fitted with Wright-Jaentsch centrifugal agitators, the rest with ordinary stirrers only. In both cases the agitating gear is carried by a stem, which engages with keys in a feather on the driving shaft. This shaft passes up through the bottom of the vat, a spindle case bolted to the vat bottom surrounding it. The driving arrangement is the same as that used in the pans. The stirring gear can also be lifted or lowered in the same way. The centrifugal agitator has four 6 in. pipes set at an angle of 45° to the horizon and held by tie-rods to the stem. Their bottom ends are cut on the slant and are bolted to four



SKETCHES OF THE AGITATION VATS.

stirring arms. The rotation of the pipes induces a pumping action and effects good agitation and aeration of pulp. The top ends of the pipes should be just below the surface of the pulp for the best circulating effect. The speed of rotation of the stem is 6·7 r.p.m., and the top ends of the pipes have a peripheral speed of 350 ft. per minute. It is stated that a vat fitted with this pipe system shows an increase of 7·5% of gold dissolved in the vats over that of the ordinary form of mechanical agitator, also that the centrifugal force exerted is 6·5 lb. The other type of stirring gear has four arms at right angles, an inch or two above the bottom of the vat, and reaching to about 6 in. from the side. The frame is stiffened by cross stays. There are also four curved arms, two near the top of the vat and two half-way down. The iron of the stirrers is 3 by ½ in. With the centrifugal agitators, 3 h.p. is needed per vat to operate the gear in a filled vat. Vats have also been fitted with pipes similar in every way to those in use, but sloping toward the centre, instead of away from it. In this case 6 h.p. was needed, since centrifugal force in the solution has to be overcome. When in this position the pumping effect was very great.

The vats have 8 in. gate valves, through which solution may be taken by launders to the sump, from which the presses are filled. The thickness of the pulp is usually kept at 2·2 or 2·3 of solution to one of dry ore. With this pulp, the contents of one vat will fill 2 to 2½ presses (5·15 tons each). The filling of a vat takes from 1½ to 2 hours; the pulp is agitated for two hours; the emptying of a vat can be done in 10 minutes. When only the back row of vats is in use, owing to breakdown or stoppage of Callows, tube-mills, sump pump, etc., the pulp is discharged as soon as the vat is filled. On an average 10 vats are filled per shift, and 14 or 15 are in use at a time. The clearance between the stirring arms and the bottom of the vat, and the speed at which the arms revolve, allow the formation of a layer of heavy concentrate on the vat bottom. It pays to allow this layer to form, as it carries high gold values. This concentrate is returned through the ball-mills.

Cyanide Solution.—In the mixer, the roasted ore meets cyanide solution from the head storage tanks, up to which the zinc-box tails are pumped. These carry about 0·04% cyanide. To each full vat is added 7 lb. of cyanide normally; the amount varies from 6 to 10 lb. according to the strength of the solutions. The strength of total cyanide in the clarified solutions (zinc-box heads) should be 0·1%. If it gets below 0·075, a case of cyanide (224 lb.) is at once distributed over the full vats on the floor, usually seven or eight, in order to bring the strength up again quickly. The cyanide solution is prepared in a special mixer holding 110 gallons. When dissolved the solution is run into a tank beneath it, from which it is drawn into the vats. A case of cyanide is dissolved in the 110 gallons, so that the solution carries 2 lb. of cyanide per gallon. The consumption of cyanide is the lowest at Kalgoorlie, namely, 0·5 lb. per ton of ore treated. The lowest run for one month was 0·38 lb. per ton. The disadvantage of using solutions low in cyanide is that the precipitation in the zinc-boxes falls off, and though the values remain in the tail solutions, there is a greater loss of dissolved values, arising through imperfect washing of the cakes in the presses. So far as taking values into solution goes, a 0·005% solution has been found to be as effective as a 0·1% solution.

Lead Acetate.—A mixer similar to that used for the cyanide, and at its side, is used for dissolving lead acetate; 150 lb. is dissolved in 160 gallons of water, and this quantity is added to the vat solutions during 24 hours. From the mixer part of the solution is pumped to a small storage tank besides the ore and cyanide solution mixer, at the top of the building. A pipe from this tank drips lead acetate solution into the pulp solution as it leaves the mixer. One pound of lead acetate is also added to each vat as it starts to fill. The lead acetate is added in order to throw down soluble alkaline sulphides (and thiosulphates) which may be present in the solutions, mainly as a result of bad roasting. These sulphides give rise to the formation of thiocyanate, with consequent inferior precipitation in the zinc-boxes, and also destroy cyanide, with the production of hydrocyanic acid. The presence of precipitated lead sulphide in the slime has not definitely been shown. Lead sulphate is believed to play some part in the reaction.

Lime.—Two bags of lime are slacked on a screen over No. 1 vat, and the $Ca(OH)_2$ washed through into the vat, every shift. The roasted ore is either neutral, or very faintly alkaline. The lime is added to make it distinctly alkaline, and to prevent absorption of carbonic acid, which acts as a cyanicide. Lime also prevents sulphate of lime contained in the pulp from going into solution and depositing later on in pipes, on filter-press plates and cloths, etc. The sulphate of lime in the roasted ore arises from the combinations of lime due to the carbonate in raw ore with sulphur compounds in the roasting furnaces. The roasted ore contains about 0·2% lime; if it runs high in lime, it usually runs low in sulphur. Ferric sulphate, which might be expected as an oxidation product of FeS_2, and would tend to make roasted ore acid in reaction, has not definitely been proved. FeS is known to be present in the roasted ore. Lime is determined in the clarifier solutions every shift, and should not be below 0·005 per cent.

(To be concluded).

SPECIAL CORRESPONDENCE

JOHANNESBURG.

RAND MINING ECONOMICS.—The members of the South African Institution of Engineers have been entertained by the reading of a breezy and interesting paper by Mr. George A. Denny on "Rand Economics: Some Salient Unappreciated Issues." The avowed object of the paper was to provoke discussion, and to draw attention to one or two features of Rand mining which Mr. Denny claims have been somewhat overlooked. The author is a pioneer engineer of the Rand, who spent a considerable time in the Klerksdorp district in the early days, and afterward was identified with the Albu group. In the adopted role of free lance and critic much that he says will be sure to attract attention.

He mentioned the fact that, between 1902 and 1915, working costs on the Rand were reduced by 8s. 4d. per ton, while the yield during the same period fell by no less than 15s. 9d. per ton. He asked how much of this reduction per ton in working costs was really due to a genuine saving of expenditure, and to what extent it was due to the milling of cheaply mined ore of unprofitable grade, possibly producing less gold than paid to handle it, with the sole object of creating a big divisor and a corresponding low working cost per ton. This, as Mr. Denny must know, is a difficult question to answer in detail, but he may take it for granted that there are few mining men on the Rand who would knowingly mill worthless ore with the sole object of reducing the working costs per ton. It must be pointed out that in the last days of a mine on the Rand, development costs cease, old pillars are extracted, and both working costs and values decline, and since Mr. Denny left the Rand there has been a good deal of this kind of work going on. That there have during Mr. Denny's absence been numerous economies introduced on the Rand, in the shape of cheaper development, motive power, fuel, etc., is beyond dispute, which must have resulted in lower working costs, while to suggest that the fall in grade may be due to the milling of worthless ore is equally misleading.

It was also alleged by Mr. Denny that there had been a quite unnecessary duplication of reduction and treatment plants. As a matter of fact, during Mr. Denny's absence from the Rand, the tendency has been rather in the other direction. Further, the concentration of milling and treatment operations at the Randfontein, Crown Mines, and elsewhere has not been such a striking success as to support Mr. Denny's views, and his suggestion to have one mill for twenty huge mines on the Far East Rand commands attention more from its boldness than promise of success.

Mr. Denny further complained that the stereotyped methods of treatment on the Rand made one feel depressed, but he admitted that Rand conditions all round are uniform and similar in all essential respects, such an admission being the best answer to the objection. Attention was also drawn to the high capital costs on the Rand, which Mr. Denny suggests would be probably reduced if the costs included the capital charges of interest and redemption. It was further urged that this fact does not induce Rand mine managers to introduce any change or reform in Rand methods. As a matter of fact there have been many changes in Rand methods of mining and treatment since Mr. Denny left the Rand some years ago, and there are not wanting instances where radical changes have been attempted in methods of treatment, as for instance at Benoni, which unfortunately ended in disaster to all concerned. It is not improbable that if any drastic changes were introduced or proposed the reply would draw attention to and quote Denny-Dalton as a warning.

Mr. Denny criticized the big-block method of development, on the ground that the big blocks are difficult to value, and suggested that these blocks should be divided into payable and unpayable areas. The fact that this method would materially increase the cost of development seems to be overlooked by Mr. Denny, while to suggest the division into small pillars of irregular shape, at the depth to which mining is fast approaching on the Rand, is not only impracticable but impossible. We must not lose sight of the fact that the paper was apparently written with the principal object of creating discussion, and on this account it is scarcely fair to be too hard on the writer.

Many engineers will, however, agree with the more rational criticism of Mr. Denny when he stated that present Rand methods of expressing values of ore reserves leave room for improvement, because the only logical symbol of value is profits. An authoritative statement that a mine had a million tons developed, estimated to yield a profit of £250,000, would mislead no one. As he said, present statements of working profits on the Rand, which do not cover the cost of sinking incline shafts, and similar necessary permanent works and other heavy items of expenditure, are misleading, while the practice of dealing with this expenditure and the methods of distributing it over the costs varies greatly among the different mining groups. Equally convincing and clear is the statement that it is quite indefensible to call ore payable because it is estimated that it may return the bare working cost as is the present practice on the Rand. Mr. Denny suggests that this method of fixing the pay limit down to the level of the bare working cost should be abolished, and that the real value of the ore reserves should be estimated not in tonnage but in terms of profit. Cost-keeping methods should be inaugurated to show the actual profits obtained from each individual developed block, and not what are obtained per ton over the average of the whole mine.

While several of Mr. Denny's suggestions are excellent, his proposal to deal with each block of developed ore on its merits will appear to the Rand mine manager as a question more of book-keeping and business than mining. It is frequently alleged, with much justification, that the control of mining operations on the Rand is more frequently placed in the hands of skilled accountants and book-keepers than mining engineers. Nevertheless, if by a new system of book-keeping as suggested by Mr. Denny the mine manager could as it were apply an X-ray to his ore reserves, it would undoubtedly be of considerable advantage. Last year's results at the Crown Mines, however, demonstrated that to practice a species of selective mining by narrowing the stoping widths and raising thereby the grade only resulted in intermittent milling with disastrous results on costs and profits. In low-grade mining propositions intermittent hauling and milling are not as a rule conducive to enhanced profits. It may be difficult to know where to draw the line sometimes, but after all it must be admitted that big-scale mining and milling has so far been the salvation of the Rand.

STATE MINING.—The reports of the State Mining Commission have been published. The fact of one majority and two minority reports being issued caused no surprise. The majority of the Commissioners are satisfied from the evidence placed before them that mining is a peculiarly risky and speculative business, and those witnesses who advocated State mining failed to prove to the satisfaction of the Commission that the Government would derive greater benefit from working the gold-bearing areas than from the present system of leasing. The majority of the Commissioners therefore do not recommend the Government of the Union of South Africa to engage directly in mining for any minerals. Providing, however, that the Government should create State mines in spite of this recommendation of the majority of the Commission, they recommend that the State mines should be financed from the General Loan Fund, that the Minister of Mines should have power to appoint an independent State Mining Board consisting of five members to assist the Minister of Mines in the supervising of the working of the State mines, and that Parliament should pass the necessary legislation to give effect to these recommendations regarding State mining.

Mr. Roos, one of the dissentients, in his report pointed out that he was in favour of the principle of State mining, the one outstanding argument against State mining being the risk and expense of gold mining. If the opponents of State mining were to succeed it seemed to him that they could succeed on this issue and no other. In the face of the figures quoted by the Government Mining Engineer, Mr. Roos did not think that where mining companies were prepared to tender, and pay for the privilege of developing mining properties, and where such had been proved to a considerable extent, the State would not be running an extravagant risk in developing its own asset. He was not, however, in favour of the State acquiring land for the privilege of mining or going in for general mining work. On the question of diamond-mining, Mr. Roos was of the opinion that where, as in the Transvaal, the Government has such a large interest, greater control should be exercised by the Government in the working of such mines. Further, that the Government should acquire by legislation full control of South African diamonds so as to obtain for the Government the fullest benefit possible from the diamond monopoly. Mr. Roos further urged that in Government leases of gold areas greater control should be exercised by the Government so as to protect its interests, but apparently he takes no exception to the recommendations of the majority report in the matter of the appointment of a Mining Board in case the Government decided to adopt State mining.

Mr. R. H. Miller's report, on the other hand, goes the whole hog in favour of State mining. The State should not lease further areas but commence mining operations in the neighbourhood of Springs at once, and gradually extend its operations toward less known areas. That State mining should be extended to all mining operations, particularly diamond mining, to be controlled by a State Mining Department consisting of capable mining men and others associated with trade unions and technical bodies.

The facts that the majority of the Commission has reported against the principle of State mining, and that the Government is not anxious to take on the additional responsibilities, make the adoption of State mining an impossibility by the present Government. In some quarters the views of Mr. Roos are received with sympathy, while in none but labour circles are the recommendations of Mr. Miller accorded support.

[The Government of the Union of South Africa has lost no time in proving its adherence to the recommendations of the majority report of the Commission. As is recorded in our Review of Mining, tenders are invited for the areas to the east and south of the Geduld and to the west and south of Springs Mines.—EDITOR]

PERSONAL.

T. J. ANDREWS is on his way to the Northern Nigeria Bauchi company's mines.

CAPTAIN H. B. BATEMAN is with the Nigerian force in "German" East Africa.

A. CHESTER BEATTY is visiting China and Japan.

CHARLES P. C. BERESFORD has been in charge of Prestea Block A as general manager since the beginning of the year.

J. M. CAIRNS is in Cornwall.

W. F. COLLINS, manager of the Filani mine, left on May 30 for Northern Nigeria.

HENRY CRIBB is at Smethwick, Birmingham, as an inspector for the Ministry of Munitions.

A. E. DRUCKER and G. W. LAWRIE have entered into partnership as metallurgical engineers, with offices at 30 Church Street, New York.

STANLEY H. FORD, manager of Fanti Consolidated, is returning shortly to West Africa.

Dr. H. F. HEATH, Secretary of the Department of Scientific and Industrial Research, has been made a K.C.B.

GEORGE T. HOLLOWAY is back from Canada.

JOHN M. ILES, manager of the Rayfield Company's properties, has left London on his return to Nigeria.

CHARLES JANIN has returned from Russia to the United States.

D. V. KEEDY is developing bauxite deposits in French Guiana for an American firm.

A. TREVELYAN KING has received a commission and has gone to the front.

E. S. KING has been appointed general manager of the Waihi Grand Junction, New Zealand.

ERNEST LEVY has re-opened his office at Spokane.

W. C. MADGE has returned to the Ridder mine by way of the United States.

R. E. PALMER is a member of the Home Iron Ore Supply Committee of the Ministry of Munitions and is in charge of the home transport of iron ore and materials for blast-furnaces from mines and quarries in the United Kingdom

S. C. PARTRIDGE has received a commission in the Tunnelling Corps of the Royal Engineers.

CAPTAIN H. G. PAYNE was home on leave from the Front for a short time last month. We offer congratulations on his being mentioned in Sir Douglas Haig's last despatch.

C. W. PURINGTON gave a lecture at King's College, London, on May 17, under the auspices of the United Russia Societies Association, on the "Pacific Routes to Siberia."

T. A. RICKARD recently visited Miami, Arizona.

F. J. ROBINSON, manager of the technical bookshop of *The Mining Magazine*, was called up for service on June 4.

RALSTON C. SHARP is in Cornwall.

HENRY C. TAYLOR has returned from India.

KIRBY THOMAS has returned from Brazil to New York.

D'ARCY WEATHERBE was in London for a short time last month, returning to New York on May 24.

We regret to record the death of JOHN H. BAIN, head of the Redruth Tin Smelting Company.

ANTON EILERS was one of the many German metallurgists who, going to the United States in their early manhood, contributed so much to the establishment of the American lead-smelting industry. He founded smelters in Colorado and Montana, and eventually he became a power with the American Smelting & Refining Company.

METAL MARKETS

COPPER.—With the market under close Government control there is naturally nothing to record as to tendencies of prices, and in fact quotations in this country are unchanged from the official figures of last month, namely: Cash standard £130–£130. 10s.; three months £129. 10s.–£130; electrolytic £142–£138; best selected £140–£136. In the United States prices showed a reactionary tendency on the whole, and from 31½c. cash, and 28½–29½ May–June, electrolytic declined to 30½–29½ cents. A slightly firmer tone was making itself felt as the month closed, but it is not sufficient to actually affect quotations. There is no news of any important buying, and it is chiefly for forward delivery that inquiry seems to be becoming more insistent. There exists a strong feeling that any attempt on the part of producers to realize higher prices will be met by the American Government giving consumers in some form or other special price advantages. The large production gives the Government the ammunition for an efficient control. For April production, although not up to record, showed, considerable advance over the figures of the previous couple of months. Consumers are impressed by this in replenishing their stocks.

Average prices of cash standard copper: May 1917, £130. 5s. 0d.; April 1917, £134. 1s. 10d.; May 1916, £135. 9s. 11d.

LEAD.—Lead is still officially quoted at £30. 10s. –£29. 10s. No business is reported in this market, the demand being supplied from Government sources. In America prices have risen, and demand is good. Of course prices are far above export parity.

Average prices of soft foreign lead: May 1917, £30.; April 1917, £30.; May 1916, £32. 19s. 5d.

TIN.—The month has seen record prices in tin, and it is felt generally that the upward movement which has continued so long has at last come to an end. Up to £254 has been paid for cash, and the most pressing demand does not seem to render such a level justified. By the end of May the quotation had fallen to £248, and an easier range of prices appears to be coming into sight. Near tin is still tight, however. It appears that this scarcity is not due to a dearth of tin in warehouse, but to the metal being earmarked against sales to consumers, and accordingly not being free for use in dealings. Demand for forward tin is poor, and there has been some pressure to sell for distant delivery. Enormous prices have been realized in New York for spot metal which bear no relation to London parity, but here also the market has become easier owing to substantial arrivals. Continental inquiry has been remarkably good, more particularly from France and Russia, but this has eased off again following the lower London quotation. China has done a large business at splendid prices. Batavia on the other hand has sold remarkably little, and shipments are reported to be under normal. From the Straits steady sales are reported.

Average prices of cash standard tin: May 1917, £245. 2s. 10d.; April 1917, £220. 3s. 10d.; May 1916, £196. 11s. 9d.

SPELTER.—The official quotation has been maintained throughout the month at £54–£50. In America the tone is toward lower prices on the whole, but the feeling is rather uncertain and what strength appears from time to time is not sustained. Production shows no sign of decreasing, and consumption is not apparently improving,

Average prices of good ordinary brands: May 1917, £52, April 1917, £52. 18s. 11d.; May 1916, £89. 11s. 4d.

NICKEL.—The quotation remains at £225 per ton.

PLATINUM.—New 290s. per oz; scrap 260s.

QUICKSILVER.—£20 to £25 per flask of 75 lb.

BISMUTH.—11s. per lb. CADMIUM 8s. per lb.

COBALT.—10s. per lb. CHROMIUM 7s. 6d. per lb.

TUNGSTEN.—Powder 6s. 3d. per lb.; ferro-tungsten 5s. 6d. per lb. of tungsten contained; ore 55s. per unit.

MOLYBDENITE.—105s. per unit 90% MoS_2; ferro-molybdenum 16s. per lb.

SILVER.—The market has been devoid of feature, but the price is strong at 38d. per oz. The entry of the United States into the war is expected to create additional demand for silver for coinage purposes.

PRICES OF CHEMICALS. June 10.

Owing to the war, buyers outside the controlled firms have a difficulty in securing supplies of many chemicals, and the prices they pay are often much higher than those quoted below.

		£	s.	d.
Alum	per ton	15	0	0
Alumina, Sulphate of	,,	17	10	0
Ammonia, Anhydrous	per lb.		1	9
,, 0·880 solution	per ton	32	10	0
,, Chloride of, grey	per cwt.	1	18	0
,, ,, ,, pure	,,	3	10	0
,, Nitrate of	per ton	72	0	0
,, Phosphate of	,,	82	10	0
,, Sulphate of	,,	15	10	0
Arsenic, White	,,	75	0	0
Bleaching Powder, 35% Cl.	,,	27	0	0
Borax	,,	37	0	0
Copper, Sulphate of	,,	62	0	0
Cyanide of Potassium, 98%	per lb.		1	0
,, ,, Sodium, 100%	,,			10
Hydrofluoric Acid	,,			6
Iodine	,,		11	4
Iron, Sulphate of	per ton	4	15	0
Lead, Acetate of, white	,,	95	0	0
,, Nitrate of	,,	65	0	0
,, Oxide of, Litharge	,,	42	0	0
,, White	,,	46	0	0
Magnesite, Calcined	,,	15	0	0
Magnesium Sulphate	,,	11	0	0
Phosphoric Acid	per lb.			10
Potassium Carbonate	per ton	115	0	0
,, Chlorate	per lb.		2	6
,, Chloride 80%	per ton	65	0	0
,, Hydrate, (Caustic) 90%	,,	300	0	0
,, Nitrate	,,	75	0	0
,, Permanganate	per lb		13	6
,, Prussiate, Yellow (Ferricyanide)	,,		3	6
,, Sulphate, 90%	per ton	70	0	0
Sodium Metal	per lb		1	6
,, Acetate	per ton	85	0	0
,, Bicarbonate	,,	7	5	0
,, Carbonate (Soda Ash)	,,	7	0	0
,, ,, (Crystals)	,,	3	5	0
,, Hydrate, 76%	,,	24	10	0
,, Hyposulphite	,,	18	0	0
,, Nitrate, 95%	,,	23	10	0
,, Phosphate	,,	30	0	0
,, Silicate	,,	7	0	0
,, Sulphate (Salt-cake)	,,	2	2	6
,, ,, (Glauber's Salts)	,,	3	10	0
,, Sulphide	,,	24	0	0
Sulphur, Roll	,,	21	0	0
,, Flowers	,,	23	0	0
Sulphuric Acid, non-arsenical 140°T.	,,	4	5	0
,, non-arsenical 95%	,,	7	0	0
Superphosphate of Lime, 18%	,,	5	10	0

STATISTICS.

Production of Gold in the Transvaal.

	Rand	Elsewhere	Total	Value
	Oz.	Oz.	Oz.	£
Year 1912	8,753,563	370,731	9,124,299	38,757,560
Year 1913	8,430,998	363,826	8,794,824	37,358,040
Year 1914	8,033,567	344,570	8,378,139	35,588,075
Year 1915	8,772,919	320,752	9,073,671	38,627,461
January 1916	759,852	27,615	787,467	3,344,948
February	727,346	26,248	753,594	3,201,063
March	768,714	27,975	796,689	3,384,121
April	728,399	26,273	754,672	3,205,643
May	751,198	26,483	777,681	3,303,377
June	735,194	26,570	761,764	3,235,767
July	733,485	27,602	761,487	3,232,891
August	752,940	28,210	781,150	3,318,116
September	744,881	26,686	771,567	3,277,408
October	764,489	27,850	792,339	3,365,642
November	756,370	26,696	783,066	3,326,253
December	748,491	25,971	774,462	3,289,705
Year 1916	8,971,359	324,179	9,295,538	39,484,934
January 1917	756,997	25,637	782,634	3,324,418
February	696,955	24,366	721,321	3,063,976
March	760,598	26,496	787,094	3,343,363
April	717,598	25,180	742,778	3,155,121

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
January 31, 1916	209,835	9,228	802	219,865
February 29	209,426	9,468	970	219,864
March 31	203,575	9,588	917	214,080
April 30	199,936	9,827	938	210,701
May 31	194,765	9,811	1,459	206,035
June 30	192,809	9,859	2,105	204,773
July 31	192,130	9,932	3,339	205,401
August 31	194,112	10,086	5,146	209,344
September 30	197,734	10,239	6,527	214,500
October 31	199,330	10,907	6,358	216,595
November 30	196,132	11,118	5,928	213,178
December 31	191,547	11,487	5,194	208,228
January 31, 1917	188,624	11,611	5,591	205,826
February 28	191,095	11,568	6,268	208,931
March 31	190,028	11,494	6,620	208,142
April 30	185,975	11,435	6,314	203,724

Cost and Profit on the Rand.

Compiled from official statistics published by the Transvaal Chamber of Mines. The profit available for dividends is about 60% of the working profit.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
Year 1912	25,486,361	29 2	19 3	9 11	12,678,095
Year 1913	25,628,432	27 9	17 11	9 6	12,189,105
Year 1914	25,701,954	26 6	17 1	9 0	11,553,697
Year 1915	28,314,539	26 3	17 5	8 5	11,931,062
July 1916	2,370,244	26 1	17 10	8 0	949,606
August	2,423,669	26 3	17 10	8 1	976,125
September	2,367,793	26 6	18 0	8 3	972,704
October	2,453,437	26 4	17 10	8 2	1,001,843
November	2,389,056	26 9	18 2	8 2	980,387
December	2,349,191	26 10	18 2	8 4	977,481
January 1917	2,337,066	26 10	18 8	7 11	941,520
February	2,153,691	27 3	19 2	7 10	841,259
March	2,430,590	26 7	19 0	7 4	879,351

Production of Gold in Rhodesia and West Africa

	Rhodesia.		West Africa.	
	1916	1917	1916	1917
	£	£	£	£
January	318,586	296,113	140,579	131,665
February	313,769	289,734	137,739	104,892
March	335,368	300,183	150,987	158,727
April	339,386	297,977	135,976	123,825
May	323,783	...	132,976	...
June	333,070	...	127,107	...
July	322,365	...	128,574	...
August	338,001	...	125,143	...
September	322,035	...	127,138	...
October	325,608	...	132,577	...
November	317,135	...	130,101	...
December	306,205	...	146,409	...
Total	3,895,311	1,184,007	1 615,306	519,109

West Australian Gold Statistics.

	Reported for Export oz.	Delivered to Mint oz.	Total oz.	Total value £
January 1916	1,861	92,124	93,985	399,220
February	2,832	65,138	67,970	288,717
March	5,600	88,393	93,993	399,255
April	2,926	87,601	90,527	384,532
May	577	83,301	83,878	356,289
June	2,070	92,612	94,682	402,181
July	912	91,725	92,637	393,495
August	*	89,522	*	*
September	*	85,978	*	*
October	*	82,732	*	*
November	*	87,322	*	*
December	*	88,205	*	*
January 1917	*	83,962	*	*
February	*	81,810	*	*
March	*	76,171	*	*
April	*	82,144	*	*
May	*	78,165	*	*

* By direction of the Federal Government the export figures will not be published until further notice.

Australian Gold Returns.

	Victoria.		Queensland.		New South Wales	
	1916	1917	1916	1917	1916	1917
	£	£	£	£	£	£
January	89,900	...	66,700	50,150	39,000	29,000
February	76,500	...	79,050	63,200	30,000	26,000
March	103,600	...	76,920	61,200	36,000	41,000
April	60,000	...	83,300	62,470	63,000	21,000
May	119,500	...	116,230	...	19,000	...
June	86,000	...	72,200	...	18,000	...
July	100,600	...	85,400	...	23,000	...
August	66,800	...	86,000	...	24,000	...
September	115,100	...	65,450	...	32,000	...
October	81,400	...	74,800	...	32,000	...
November	94,000	...	60,300	...	31,000	...
December	96,600	...	73,550	...	111,000	...
Total	1,090,000	...	940,500	236,970	459,000	116,000

Production of Gold in India.

	1914	1915	1916	1917
	£	£	£	£
January	193,140	201,255	192,150	190,047
February	185,508	195,970	183,264	180,904
March	191,853	194,350	186,475	189,618
April	189,197	196,747	192,208	185,835
May	193,031	199,786	193,604	184,874
June	192,224	197,447	192,469	...
July	195,137	197,056	191,404	...
August	196,560	197,984	192,784	...
September	195,843	195,952	192,330	...
October	198,191	195,531	191,502	...
November	197,699	192,714	192,298	...
December	211,911	204,590	205,164	...
Total	2,340,259	2,366,457	2,299,568	931,278

Daily London Metal Prices

Copper, Lead, Zinc, Tin, in £ per long ton. Silver in pence per standard ounce.

	Copper Standard	Copper Electrolytic	Copper Best Select'd	Soft For'n Lead	Zinc	Tin Standard	Silver
May	£	£	£	£ s.	£ s.	£ s. d.	d.
9	130	142	140	30 10	54 0	234 15 0	37$\frac{15}{16}$
10	130	142	140	30 10	54 0	240 5 0	37$\frac{7}{8}$
11	130	142	140	30 10	54 0	243 0 0	37$\frac{7}{8}$
14	130	142	140	30 10	54 0	246 15 0	38
15	130	142	140	30 10	54 0	252 15 0	38
16	130	142	140	30 10	54 0	256 5 0	38
17	130	142	140	30 10	54 0	252 5 0	38
18	130	142	140	30 10	54 0	250 5 0	37$\frac{7}{8}$
21	130	142	140	30 10	54 0	251 10 0	38
22	130	142	140	30 10	54 0	254 0 0	37$\frac{7}{8}$
23	130	142	140	30 10	54 0	255 5 0	37$\frac{7}{8}$
24	130	142	140	30 10	54 0	255 0 0	37$\frac{7}{8}$
25	130	142	140	30 10	54 0	253 15 0	37$\frac{7}{8}$
29	130	142	140	30 10	54 0	253 5 0	37$\frac{7}{8}$
30	130	142	140	30 10	54 0	253 10 0	38
31	130	142	140	30 10	54 0	253 10 0	38
June							
1	130	142	140	30 10	54 0	248 0 0	38
4	130	142	140	30 10	54 0	239 10 0	38$\frac{3}{16}$
5	130	142	140	30 10	54 0	235 0 0	38$\frac{1}{8}$
6	130	142	140	30 10	54 0	237 0 0	38$\frac{1}{8}$
7	130	142	140	30 10	54 0	238 10 0	38$\frac{1}{4}$
8	130	142	140	30 10	54 0	238 10 0	38$\frac{3}{8}$

IMPORTS OF ORES AND METALS INTO UNITED KINGDOM.

These figures do not include Government imports.

Long tons.

	Year 1916	March 1917	April 1917	Year 1917
	Tons	Tons	Tons	Tons
Iron Ore	6,905,936	494,188	522,289	2,035,841
Copper Ore	34,492	1,717	777	6,130
,, Matte and Precipitate	43,839	1,973	3,997	9,308
,, Metal	111,412	7,142	9,776	31,915
Copper and Iron Pyrite	951,206	70,758	84,928	334,586
Tin Concentrate	33,912	2,641	2,584	13,194
,, Metal	33,646	2,765	3,495	10,666
Manganese Ore	439,509	35,879	24,904	122,597
Lead, Pig and Sheet	157,985	7,127	14,744	43,887
Zinc (spelter)	53,324	3,691	5,805	20,604
	lb.	lb.	lb.	lb.
Quicksilver	2,556,214	15,100	7,504	72,448

EXPORTS OF COPPER FROM UNITED STATES

Reported every month by the United States Customs.

1916	Long tons	1916	Long tons	1917	Long tons
January	21,863	July	35,048	January	25,540
February	20,548	August	34,700	February	24,937
March	24,006	September	28,572	March	51,246
April	19,980	October	32,712	April	—
May	14,700	November	21,433	May	—
June	38,277	December	21,438	June	—
		Total 1916	313,277	Total 1917	101,723

OUTPUTS OF TIN MINING COMPANIES.

In Tons of Concentrate.

	Year 1916	Jan. 1917	Feb. 1917	Mar. 1917	April 1917
	Tons	Tons	Tons	Tons	Tons
Bisichi (Nigeria)	473	40	32	30	25
Briseis (Tasmania)	467	34	30	33	30
Dolcoath (Cornwall)	1,076	60	62	68	70
East Pool (Cornwall)*	1,012	88	87	94	90
Gopeng (F.M.S.)	1,113	92	76	73	79
Malayan Tin (F M.S.)	1,104	65	62	59	50
Mongu (Nigeria)	576	60	60	60	42
Naraguta (Nigeria)	523	48	44	40	32
N. N. Bauchi (Nigeria)	578	45	40	45	40
Pahang (F.M.S.)	2,591	220	220	220	220
Rayfield (Nigeria)	658	50	50	50	50
Renong (Siam)	894	82	61	73	77
Siamese Tin (Siam)	906	81	73	75	68
South Crofty (Cornwall)*	700	55	55	59	55
Tekka-Taiping (F.M.S.)	651	47	30	30	30
Tongkah Harbour (Siam)	1,135	96	87	147	131
Tronoh (F.M.S.)	1,662	108	83	76	75

* Including Wolfram.

STOCKS OF TIN.

Reported by A. Strauss & Co. Long tons.

	Mar. 31, 1917	April 30 1917	May 31, 1917
	Tons	Tons	Tons
Straits and Australian, Spot	1,735	2,758	2,149
Ditto, Landing and in Transit	1,245	879	1,255
Other Standard, Spot and Landing	694	401	359
Straits, Afloat	5,314	3,845	5,617
Australian, Afloat	425	325	85
Banca, on Warrants	—	—	—
Ditto, Afloat	3,738	3,130	1,541
Billiton, Spot	—	—	—
Ditto, Afloat	117	100	100
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	1,121	1,535	1,455
Afloat for United States	3,455	3,835	3,339
Stock in America	3,362	1,707	4,402
Total Stock	21,206	18,515	20,302

SHIPMENTS AND IMPORTS OF TIN

Reported by A. Strauss & Co. Long tons.

	Year 1916	May 1917	Total 1917
	Tons	Tons	Tons
Shipments from:			
Straits to U.K.	27,157	3,522	13,361
Straits to America	25,943	2,234	9,252
Straits to Continent	8,487	1,110	4,850
Australia to U.K.	2,537	—	349
U.K., Holland, and Continent to America	14,863	575	5,990
Imports of China Tin into U.K. and America	1,305	95	110
Imports of Bolivian Tin into Europe	15,116	1,329	6,976
Deliveries in U.K.	16,862	1,801	5,191
,, ,, Holland	943	82	453

NIGERIAN TIN PRODUCTION.

In long tons of concentrate of unspecified content.

Note. These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1912	1913	1914	1915	1916	1917
	Tons	Tons	Tons	Tons	Tons	Tons
January	204	466	485	417	531	648
February	240	427	469	358	528	627
March	247	510	502	418	547	640
April	141	430	482	444	486	522
May	144	360	480	357	536	...
June	121	321	460	373	510	...
July	140	357	432	455	506	...
August	201	406	228	438	498	...
September	196	422	289	442	535	...
October	256	480	272	511	584	...
November	340	446	283	467	679	...
December	310	478	326	533	654	...
Total	2,540	5,103	4,708	5,213	6,594	2,437

PRODUCTION OF TIN IN FEDERATED MALAY STATES.

Estimated at 70% of Concentrate shipped to Smelters.

Long Tons.

	1913	1914	1915	1916	1917
	Tons	Tons	Tons	Tons	Tons
January	4,121	4,983	4,395	4,316	3,558
February	3,823	3,555	3,780	3,372	2,755
March	3,562	3,839	3,653	3,696	3,286
April	4,066	4,087	3,619	3,177	3,251
May	4,319	4,135	3,823	3,729	3,413
June	3,993	4,303	4,048	3,435	...
July	4,245	4,582	3,544	3,517	...
August	4,620	3,591	4,046	3,732	...
September	4,379	3,623	3,932	3,636	...
October	4,409	3,908	3,797	3,681	...
November	3,976	4,085	4,059	3,635	...
December	4,614	4,351	4,071	3,945	...
	50,127	49,042	46,767	43,871	16,263

SALE OF TIN CONCENTRATE AT REDRUTH TICKETINGS.

	Long tons	Value	Average
Year 1915	4,918	£448,362	£90 14 6
July 3, 1916	179	£17,477	£97 12 10
July 17	186½	£17,114	£91 15 4
July 31	172¼	£16,172	£93 17 8
August 14	166	£15,955	£96 2 4
August 28	180¼	£17,345	£96 4 8
September 11	184	£17,113	£93 0 2
September 25	166½	£15,980	£95 19 7
October 9	197	£19,443	£98 13 11
October 23	170	£17,167	£100 19 9
November 8	194½	£19,701	£101 5 10
November 20	172	£18,044	£104 18 2
December 4	160½	£16,588	£105 4 6
December 18	186¼	£19,031	£102 3 8
Total, 1916	4,668	£478,194	—
January 2, 1917	176	£17,677	£100 8 10
January 15	160¾	£16,681	£103 15 5
January 29	152	£16,095	£105 17 10
February 12	182¼	£20,649	£113 6 1
February 26	176¾	£19,700	£111 9 3
March 12	179	£20,468	£114 7 0
March 26	161¾	£19,875	£122 17 8
April 10	179	£22,024	£123 2 0
April 23	169	£21,429	£126 16 0
May 7	167	£22,248	£133 4 6
May 21	168¼	£23,772	£141 5 9
June 4	168	£22,474	£133 15 6

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	June 5, 1916 £ s. d.	June 5, 1917 £ s. d.
RAND:		
Bantjes	13 9	9 0
Brakpan	4 2 6	5 1 3
Central Mining (£8)	6 7 6	6 7 6
Cinderella	6 6	4 6
City & Suburban (£4)	1 17 0	1 12 6
City Deep	3 19 6	4 8 0
Consolidated Gold Fields	1 8 0	1 12 0
Consolidated Langlaagte	1 14 6	1 2 6
Consolidated Main Reef	19 6	17 0
Consolidated Mines Selection (10s).	17 0	1 4 3
Crown Mines (10s.)	3 1 3	2 11 3
Daggafontein	15 6	17 0
D. Roodepoort Deep	14 6	11 3
East Rand Proprietary	14 9	9 9
Ferreira Deep	1 10 0	1 0 0
Geduld	2 5 3	2 2 3
Geldenhuis Deep	1 4 6	1 3 0
Gov't Gold Mining Areas	1 17 6	3 1 0
Heriot	2 12 6	2 1 3
Jupiter	6 0	6 0
Kleinfontein	1 7 6	1 3 0
Knight Central	12 0	8 0
Knight's Deep	1 8 9	17 6
Langlaagte Estate	19 6	16 6
Luipaard's Vlei	9 3	7 6
Main Reef West	7 6	4 9
Meyer & Charlton	5 11 3	5 6 3
Modderfontein (£4)	17 0 0	21 10 0
Modderfontein B	6 17 0	7 15 0
Modder Deep	6 15 0	7 2 6
Nourse	15 0	1 3 0
Rand Mines (5s.)	3 10 0	3 8 9
Rand Selection Corporation	3 6 3	3 17 6
Randfontein Central	10 9	13 6
Robinson (£5)	1 0 0	1 0 0
Robinson Deep	1 0 0	1 12 6
Rose Deep	1 4 6	19 6
Simmer & Jack	7 6	6 9
Simmer Deep	2 0	3 9
Springs	2 13 9	3 0 6
Van Ryn	2 5 0	1 18 9
Van Ryn Deep	3 9 6	3 6 3
Village Deep	1 12 6	1 5 6
Village Main Reef	17 6	14 6
Witwatersrand (Knight's)	3 0 6	2 2 6
Witwatersrand Deep	1 5 0	14 6
Wolhuter	11 0	10 0
OTHER TRANSVAAL GOLD MINES:		
Glynn's Lydenburg	17 0	15 0
Sheba (5s.)	2 3	1 3
Transvaal Gold Mining Estates	1 3 0	15 0
DIAMONDS IN SOUTH AFRICA:		
De Beers Deferred (£2 10s.)	11 0 0	14 0 0
Jagersfontein	3 7 6	4 5 0
Premier Deferred (2s. 6d.)	5 2 6	7 10 0
RHODESIA:		
Cam & Motor	13 6	8 9
Chartered British South Africa	12 3	12 0
Eldorado	11 0	8 3
Falcon	13 0	14 6
Gaika	12 6	8 6
Giant	7 0	5 3
Globe & Phœnix (5s.)	1 4 6	1 10 0
Lonely Reef	1 3 9	1 3 6
Shamva	1 15 0	1 3 9
Wanderer (3s.)	1 6	2 0
Willoughby's (10s.)	5 0	5 6
WEST AFRICA:		
Abbontiakoon (10s.)	7 3	5 0
Abosso	10 0	9 0
Ashanti (4s.)	18 3	19 3
Prestea Block A	9 3	6 0
Taquah	18 3	17 0
WEST AUSTRALIA:		
Associated Gold Mines	5 0	3 0
Associated Northern Blocks	4 3	2 9
Bullfinch	5 0	2 0
Golden Horse-Shoe (£5)	1 17 6	1 18 9
Great Boulder Proprietary (2s.)	13 9	11 3
Great Boulder Perseverance	1 0	1 3
Great Fingall (10s).	2 0	1 0
Ivanhoe (£5)	2 3 9	2 2 6
Kalgurli	12 0	9 3
Sons of Gwalia	16 3	13 9

GOLD, SILVER, *cont.*	June 5, 1916 £ s. d.	June 5, 1917 £ s. d.
OTHERS IN AUSTRALASIA:		
Mount Boppy, New South Wales	6 0	6 0
Talisman, New Zealand	12 6	11 3
Waihi, New Zealand	1 17 0	1 14 6
Waihi Grand Junction, New Z'lnd	18 9	14 9
AMERICA:		
Alaska Treadwell (£5), Alaska	6 7 6	1 15 0
Buena Tierra, Mexico	12 6	10 0
Camp Bird, Colorado	9 9	6 6
Casey Cobalt, Ontario	7 0	5 6
El Oro, Mexico	10 0	9 0
Esperanza, Mexico	11 3	10 3
Frontino & Bolivia, Colombia	11 3	11 6
Le Roi No. 2 (£5), British Columbia	11 3	7 6
Mexico Mines of El Oro, Mexico	4 2 6	4 2 6
Oroville Dredging, California	15 9	15 9
Plymouth Consolidated, California	1 3 0	1 2 0
St. John del Rey, Brazil	15 6	16 6
Santa Gertrudis, Mexico	15 0	10 0
Tomboy, Colorado	1 3 6	18 9
RUSSIA:		
Lena Goldfields	1 12 6	1 15 0
Orsk Priority	16 3	1 1 3
INDIA:		
Champion Reef (2s. 6d.)	6 9	5 9
Mysore (10s.)	3 18 6	3 8 9
Nundydroog (10s.)	1 9 3	1 6 6
Ooregum (10s.)	1 2 0	1 0 3

COPPER:

	June 5, 1916	June 5, 1917
Anaconda (£10), Montana	17 10 0	—
Arizona Copper (5s.), Arizona	2 0 0	2 9 6
Cape Copper (£2), Cape Province	3 15 0	4 5 0
Chillagoe (10s.), Queensland	6	3
Cordoba (5s.), Spain	4 3	3 0
Great Cobar (£5), N.S.W.	3 6	2 3
Hampden Cloncurry, Queensland	2 4 0	1 10 6
Kyshtim, Russia	2 5 0	2 1 3
Messina (5s.), Transvaal	11 6	10 0
Mount Elliott (£5), Queensland	4 5 0	6 0 0
Mount Lyell, Tasmania	1 9 9	1 5 6
Mount Morgan, Queensland	2 1 6	1 13 9
Rio Tinto (£5), Spain	61 0 0	61 15 0
Sissert, Russia	18 9	1 5 0
Spassky, Russia	2 0 0	1 15 0
Tanalyk, Russia	2 2 6	1 18 9
Tanganyika, Congo and Rhodesia	2 10 0	3 12 0
Tharsis (£2), Spain	5 0 0	5 0 0

LEAD-ZINC:

	June 5, 1916	June 5, 1917
BROKEN HILL:		
Amalgamated Zinc	1 10 6	1 11 6
British Broken Hill	1 5 6	1 14 9
Broken Hill Proprietary (8s.)	2 19 3	2 5 0
Broken Hill Block 10 (£10)	1 3 9	1 2 6
Broken Hill North	2 8 3	2 13 6
Broken Hill South	8 2 6	8 7 6
Sulphide Corporation (15s.)	1 4 9	1 6 3
Zinc Corporation (10s.)	14 6	1 0 6
ASIA:		
Burma Corporation	2 12 6	3 18 9
Irtysh Corporation	2 0 0	1 17 0
Russian Mining	17 0	17 6
Russo-Asiatic	5 2 6	4 6 3

TIN:

	June 5, 1916	June 5, 1917
Aramayo Francke, Bolivia	1 6 3	1 13 9
Bisichi, Nigeria	9 0	15 3
Briseis, Tasmania	5 3	5 3
Dolcoath, Cornwall	12 6	10 0
East Pool, Cornwall	1 13 9	2 0 0
Ex-Lands Nigeria (2s.), Nigeria	1 6	2 0
Geevor (10s.) Cornwall	—	13 3
Gopeng, Malay	1 11 3	1 11 3
Ipoh Dredging, Malay	19 6	16 3
Malayan Tin Dredging, Malay	2 3 9	1 18 9
Mongu (10s.), Nigeria	8 9	14 0
Naraguta, Nigeria	15 0	14 3
N. N. Bauchi Pref. (10s.), Nigeria	6 3	9 9
Pahang Consolidated (5s.), Malay	9 9	11 9
Rayfield, Nigeria	6 3	7 0
Renong Dredging, Siam	1 10 0	2 6 3
Ropp (4s.), Nigeria	16 9	18 3
Siamese Tin, Siam	2 16 3	2 15 0
South Crofty (5s.), Cornwall	14 9	1 1 0
Tekka, Malay	3 0 0	3 2 6
Tekka-Taiping, Malay	2 5 0	2 17 6
Tronoh, Malay	1 13 9	1 6 3

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also reviews of new books, and abstracts of the yearly reports of mining companies.

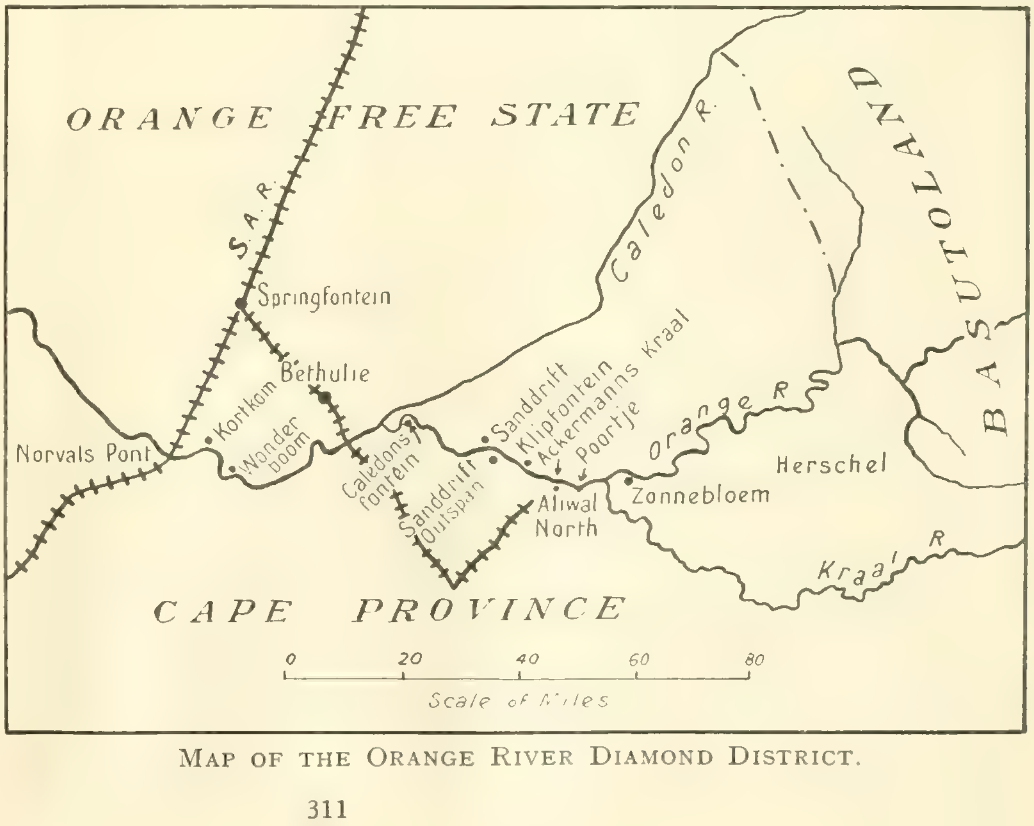
THE ORANGE RIVER DIAMOND DEPOSITS.

Much has been heard recently of new diamond discoveries in the neighbourhood of Aliwal North, on both sides of the Orange River. Dependable information is now to hand in an article by Dr. P. A. Wagner, published in the *South African Mining Journal* for February 17 and 24, and March 10. We quote at some length from this article.

That the extensive accumulations of gravel in the upper part of the Orange River valley carry diamonds was discovered accidentally in June 1914, by the finding of a rather valuable stone in a railway cutting that was being made on the farm Poortje, some little distance to the north-west of the Frere Bridge across the Orange at Aliwal North. Since then a good deal of prospecting has been done on both banks of the river, and diamonds have been found as far down stream as the farm Kortkom, situated between Bethulie Bridge and Norvals Pont, a distance, measured along the river, of 110 miles below Aliwal North. Kortkom lies about 160 miles above the farm De Kalk, on the Orange River near Hope Town, the scene in the year 1867 of the finding of the first South African diamond. No finds have as yet been made between these points, but as promising gravel deposits exist at a number of localities it appears not improbable that diamonds will also be discovered along this section of the Orange. As regards the upper limit of the diamond-bearing gravels, the belief was long prevalent among diggers that nothing would be found above Poortje. Recently, however, a number of diamonds, including one of 2½ carats, were recovered from an ancient gravel deposit on the farm Zonnebloem, situated on the southern bank of the Orange, about 10 miles above Aliwal. Three stones are also alleged to have been found well above Zonnebloem, somewhere near the western boundary of the Herschel district, but Dr. Wagner was able neither to confirm this nor to ascertain the exact locality of the alleged finds.

In view of the considerable distance between the extreme points at which diamonds have been found, surprise has been expressed in many quarters that it took so long to discover that the Orange River gravels are diamondiferous. It should, however, be pointed out that the distribution of the stones in the alluvium is extraordinarily sparse and erratic. They are far rarer than they are, for example, in the alluvial deposits of Griqualand West, and are practically confined to small patches of gravel, occurring, as a rule, at a fairly great elevation above the present level of the stream. These patches were clearly laid down under conditions specially favouring the transportation and concentration of heavy particles. Such patches are few and far between, and are scattered haphazard through the more normal gravels, which appear to be barren. Most of the rich patches so far discovered in the neighbourhood of Aliwal North are situated at an elevation of between 70 and 85 ft. above the present level of the river, which suggests that, during the particular period when the bed of the Orange was at this level, the river may have flowed with an exceptionally strong current.

The whole of the area under review is occupied by practically horizontal shales and sandstones belonging to the Burghersdorp Beds (Beaufort Series) of the Karroo System, and dykes and sills of dolerite intrusive in them. There is a network of dolerite dykes, and these have played an important rôle in determining the position of the gravel deposits along the Orange. For while the river has been able readily to deepen its channel in the soft Karroo shales and sandstones, the resistant dykes of dolerite, in addition to acting as riffles, have, by checking downward erosion, caused the stream to wind about in great loops and to swing from one side of its valley to the other, thus providing favourable conditions for the deposition on a large scale of terrace or bench gravels. These are generally found on the up-stream side of the dykes, at elevations of up to 300 ft. above the present level of the stream. It is by no means uncommon, however, also to find



MAP OF THE ORANGE RIVER DIAMOND DISTRICT.

deposits on the down-stream side of the dolerite intrusions. This is the case, for example, with the rich gravel on the Sanddrift Outspan, and also with the diamond-bearing alluvium on the farm Zonnebloem. The terrace gravels, as a rule, are more or less distinctly stratified, and are not infrequently interbedded with sand and grit. Their thickness varies from a few inches to as much as 35 ft. in depressions in former channels of the river. In some localities the gravel is spread as a thin, continuous layer over terraces occurring at different elevations, and over the slopes connecting these, thus giving inexperienced observers the impression that it is of very considerable thickness. Fairly extensive patches of coarse unstratified wash also occur in the existing bed of the river, and are being worked at several localities. The material of which they are composed appears to have been derived in great part from the denudation of older terrace gravels.

The gravel everywhere presents much the same features though it naturally varies somewhat in composition according to locality. It is generally found to be made up of well-rounded boulders of igneous and sedimentary rocks, in some instances attaining a diameter of 3 ft. which, together with smaller pebbles of various rocks and minerals, are set in a sandy, clayey, or calcareous matrix. The amygdaloidal basalts (Drakensberg lavas) occurring at the top of the Karroo succession in Basutoland have invariably contributed a considerable proportion of the larger boulders and pebbles, as well as much of the finer material, including agates, differently coloured varieties of chalcedony, white quartz, calcite, and different zeolites. Other rocks represented in the gravels are dolerite, sandstone, quartzitic sandstone, indurated shale, and petrified wood. Boulders of dolerite not infrequently preponderate, this being particularly the case below instrusions of that rock. Most important among the finer constituents of the gravel, from the point of view of the diamond digger, are the so-called Orange River "bantams." These are pebbles of a hard, heavy rock of deep brownish-yellow colour, sometimes mottled with green. Microscopic examination reveals the rock of which the bantams are composed to be a ferruginous, sandy slate or indurated shale. They are thus totally different from the true Vaal River bantams, which are pebbles of a very fine grained, banded garnet-quartz rock. The specific gravity of the bantams varies with the amount of iron as limonite present, from 3·1 to 3·5. New arrivals on the diggings are urged to make themselves thoroughly familiar with the appearance of these pebbles, which, being of approximately the same specific gravity as the diamond, by their presence in or absence from any particular occurrence of gravel enable one to form a very good idea of whether or not it is likely to prove diamondiferous. Of the deposits hitherto exploited only those in which bantams are fairly abundant have been found to contain diamonds, and it follows therefore that gravel in which no bantams are visible, or which on being roughly tested fails to yield any, is not worth working. The association of diamond and bantam is well illustrated by the rich gravel on the Sanddrift Outspan which, as already pointed out, was clearly deposited under conditions very favourable to the concentration of heavy particles. It is made up of large boulders of dolerite up to 3 ft. in diameter, set in a ferruginous clayey matrix of reddish-brown colour, crowded with bantams, and patches and layers composed of these occur between the boulders.

Grains of deep red garnet and of bluish-black ilmenite (known as "carbon"), derived without doubt from the denudation of pipes and dykes of kimberlite, are met with throughout the whole extent of the diggings. The grains, as a rule, are well rounded and worn, and give one the impression of having suffered a lengthy transport. Limonite pseudomorphs after crystals of pyrite are fairly common in the concentrate obtained on washing the gravel.

Up to the time of writing the Orange River deposits have produced diamonds to the value of about £11,500. The largest stone so far found weighed 63 carats and was sold for £365. It was picked up on the farm Poortje, in the patch of gravel in which the original discovery was made. The best stone hitherto recovered was found on the Sanddrift Outspan. It weighed 22 carats and realized £516. Another 27½-carat stone from the same locality was sold for £500. The diamonds appear to become smaller as one proceeds down-stream, but the evidence on this point can at present hardly be said to be conclusive. The average size and value of the stones are said by buyers to be much the same as on the Vaal River fields. As regards crystallization, stones of octahedral and dodecahedral habit predominate; the faces of the dodecahedra being frequently ridged in the direction of the shorter diagonal which makes them approximate in shape to tetrahexahedra. Flattened heart-shaped crystals and "maacles" are also very common.

Compared with the product of the alluvial deposits in the basin of the Vaal, the Orange River parcels are characterized by the preponderance of yellow and brown diamonds, by the presence of peculiar "oily" or opalescent stones, closely resembling those found in the Premier mine, and by the almost complete absence of cleavage, though broken crystals are by no means uncommon. Blue-white diamonds appear to be rather rare; fine-whites, on the other hand, are very much in evidence. Many of the stones are spotted. Bort is rare. The character of the diamonds appears to be much the same throughout the diggings. In a parcel from Kortkom, however, Dr. Wagner noticed two stones differing in their crystalline form from any that he saw from the deposits in the neighbourhood of Aliwal North. One of these was a small white octahedron with sharp-edged terraced faces, closely resembling some of the octohedra found in the Jagersfontein mine, the other a peculiar rough-looking cubical crystal, of a type very unusual in South Africa, but of fairly common occurrence in the alluvial deposits of Brazil. Some experts maintain that there is a fairly close resemblance between the Orange River diamonds and the better class of Premier diamonds, but Dr. Wagner says that, apart from the oily stones, he did not see any great similarity.

The problem of the origin of the Orange River diamonds, while similar to that of the origin of the stones found in the basin of the Vaal, is on the whole far more simple. For while a certain proportion of the Vaal River stones may possibly have been derived from the denudation of the ancient pre-Karroo rocks exposed in Griqualand West and the South-Western Transvaal, the whole of the upper portion of the Orange River basin is occupied by rocks belonging to the Karroo system. It is quite evident therefore that the Orange River diamonds must have been derived either from the Karroo beds themselves or from igneous rocks intrusive in them. Professor Schwarz, of Grahamstown, recently claimed to have found small diamonds in the so-called felspar bed of the Molteno sandstones, and as this stratum must originally have been present over the whole of the area now under consideration, some of the Orange River diamonds may conceivably have been derived from it. The invariable presence in the diamond-bearing gravel of grains of so-called "carbon" (ilmenite) and pyrope garnet suggests, however, that the bulk of the stones have been derived from the denudation of one or more occurrences of kimberlite, either pipes or dykes. A dyke of kimberlite was recently opened up on the farm Boschberg, No. 60, and there is another on Ackermann's Kraal. They are, however, both barren, and therefore of no interest from our point of view. Grains of garnet and ilmenite occur in the river bed on the farm Geneva, about five miles above Aliwal North, and garnets are associated with the diamonds found on Zonnebloem. The source of some at any rate of the Orange River diamonds would thus appear to lie well above Zonnebloem ; and, if the story of the alleged finding of three diamonds near the western boundary of the Herschel district be correct, also above that. Both the Herschel district and Basutoland are closed to prospectors, and unless, therefore, the pipe or dyke of kimberlite is situated on the Free State side of the river between the western boundary of the Herschel district and the Basutoland border, there is no likelihood of its being discovered in the near future.

The question next arises whether a primary occurrence situated farther down stream may not have contributed a portion of the diamonds. The circumstance that grains of garnet and ilmenite were fairly common in the patch of gravel in which the first diamond was found on Poortje and in a somewhat similar occurrence situated to the south-east of this, has led to the belief that there is a pipe on the farm. As a matter of fact, however, these minerals appear to have been confined to the heavy concentrated pay-wash, and the well-rounded and worn character of most of the grains that Dr. Wagner saw suggests, moreover, that they have travelled a considerable distance.

At Kortkom, garnets and ilmenite are more abundant than anywhere else on the diggings, and, as already pointed out, certain of the diamonds from this locality differ from those found higher up the river. It is possible, therefore, that there may be an undiscovered occurrence of diamond-bearing kimberlite in the neighbourhood of the farm. In this connection, sight must not, however, be lost of the fact that Kortkom is situated well below the inflow of the Caledon River, which brings down considerable quantities of deposit from the pipes in the south-eastern portion of the Orange Free State and also possibly diamonds. The evidence is thus far from being conclusive, and, in any case, there is nothing to indicate the whereabouts of the pipe if it does exist. While it is possible, therefore, that in addition to the primary occurrence which, for reasons already given, must be assumed to exist above Zonnebloem, there may be another in the Orange River basin, farther down stream, the chances of discovering either of them appear to be remote.

Dr. Wagner then proceeds to describe each individual occurrence and working in detail. He concludes by giving his opinion that these gravels are not likely to be profitable, and he utters a warning against any working on a large scale.

THE STUDY OF REFRACTORY MATERIALS.

At the May meeting of the Iron and Steel Institute, Cosmo Johns presented a paper on the properties of refractory materials. This paper formed the basis of an excellent discussion, the subject being presented in such a way as to encourage thought and to stimulate research. Though the application of the paper is intended directly for the iron and steel industries, there is so much of value in it to the non-ferrous metallurgist that we reproduce a large part of it here. The increasing use of electric heat and higher temperatures in metallurgical furnaces makes the study of refractories all the more necessary.

Writers rarely state exactly what they mean by refractory materials, so Mr. Johns starts with a definition. As metallurgical processes involve heat exchanges, and high temperatures are necessary for most of the reactions, special materials are required for the construction of the portions of the furnaces or other vessels employed that are exposed to high temperatures and are in contact with the solid, liquid, and gaseous substances taking part in the reactions. These special materials are refractory if they are capable of fulfilling the structural duties required while subjected to the high temperature necessary for the process employed, and are themselves unaltered during its progress. The conditions that prevail when metallurgical processes are being carried out vary so much, and the problems presented by the occurrence of slags sometimes basic and sometimes acid, and of atmospheres now reducing and again oxidizing, call for so many mutually exclusive properties in the refractory material employed, that only an infusible and non-volatile substance, with no volume change during variations of temperature, inert from a chemical standpoint, and with sufficient structural strength yet a non-conductor of heat, would be considered ideal. No such substance is known and probably does not exist. Hence any refractory materials employed in the metallurgical art will be the nearest approach available to the ideal for the particular process employed. And as metallurgical processes are in practice conducted on commercial lines, the refractory material employed will be that which enables a given unit of final product to be produced at the lowest cost. Fused silica and platinum are useful refractory materials in laboratory experiments, but are excluded from consideration in commerical processes for obvious reasons. In practice, therefore, the refractory material selected is never ideal and always a compromise. Mr. Johns' purpose is to discuss the properties required in any refractory materials employed, to point out their importance with a view to stimulating research, and to invite metallurgists to amplify or correct the suggestions made.

With the exception of carbon, and its compounds with silicon, which have a limited application, the available refractory substances are chiefly the oxides SiO_2, Al_2O_3, CaO, MgO, Cr_2O_5, or mixtures of these with oxides of iron, K_2O, Na_2O, and traces of other substances, regarded as impurities, some of which may function as catalysts. The materials available are therefore strictly limited ; they never occur in a state of purity in nature. Their manufacture into refractory products involves in many cases sizing, agglomeration or bonding, and final heating to a temperature that varies according to the purpose for which the product is intended and the functions it has to perform. The problems that arise are not solved by a knowledge of the properties of the compounds mentioned ; they are complicated by the presence of impurities and the varying nature of the bonding material employed. The final product, as delivered to the user, is always a mineral aggregate, often of great complexity. Such refractories possess no fusion point, but rather a range during which softening, at first incipient, at last, with increasing temperature, causes the material to fail to perform its functions. The constituents have varying melting points, and during heating they invert and new phases appear. Some inversions, involving serious volume changes, should be completed during manufacture, but often are not. This is not imputing blame to the manufacturer, for the temperatures required for such changes are rarely known, and even when known as a result of experiments under laboratory conditions, it does not follow that they apply to manufacturing processes. The art has been so long in front of the science of the refractory industry that the most urgent need at present is for an expression, in terms of scientific precision, of the most successful practice in manufacturing the refractory product and of the physico-chemical changes which take place when they are used.

Tenacity and compressive strength at ordinary temperatures are valuable only in so far as they permit the refractory products to be transported and enable them to withstand the structural stresses to which they are exposed when used. This is not difficult to attain. It is when the material is exposed to high temperatures that the value of these properties becomes most important. The abrasion caused by the movement of solid substances while in contact with their heated surfaces is important, while the erosion caused by the passage of dust-laden gases at high velocities becomes serious in time. Little or nothing is known of the conditions that favour or retard abrasion and erosion. High tenacity, which in most cases would mean that of the bonding or of the most fusible constituent, is most probably the desired property. It is the surface exposed to the highest temperature which suffers, for it is the one that is in contact with the moving solids, liquids, or gases. Compressive strength is rarely a cause of failure, for the bulk of the refractory material is at a lower temperature than the face and therefore less affected. There is, however, urgent need for accurate determination of the two properties under discussion at wide ranges of temperature for the more important materials under both oxidizing and reducing conditions.

Not less important than resistance to high temperature with concurrent abrasion and erosion is resistance to the corrosion caused by slags and gases. The effect of acid slags on basic refractories and of basic slags on acid refractories are familiar, while a most striking example might be indicated on the marked corrosion of the silica bricks in the gas ports and uptakes in open-hearth furnaces, due to the alternating passage of oxidizing and reducing gases with the resulting formation of fusible silicates. A factor conducive to rapid corrosion in the last case is the absence of large particles of silica in the bricks employed and the presence of excessive pore spaces. Here again little has been published and few observations recorded. The effect of the alkalies found in certain coals on the refractories used in coke-oven construction is serious, and here too little is known as to the real nature of the destructive influences at work.

Every element or compound used as a refractory undergoes changes in volume during heating and cooling. Apart from the fact that these volume changes may, and do at times, cause disintegration with the consequent lessening of the useful life of the material, abnormal expansion causes structural difficulties, while contraction may be even more undesirable, permitting the passage of gases from one part of the furnace to another. In the case of coke-ovens the retention of gas-tight partitions is absolutely necessary, and this involves the use of a refractory material which does not undergo appreciable volume changes. This apparent contradiction of the first statement simply means that a mixture of substances with volume changes of opposite sign are employed, namely, clay and silica. But while the contraction of the burnt clay is fairly regular with increased temperatures, quartz, which is the form of silica found associated with it in nature, has an inversion point at which it becomes tridymite. In the presence of certain compounds this inversion takes place at a temperature lower than that at which coking is carried on. In their absence the inversion is retarded and does not take place until a temperature higher than that usual in coking practice is attained.

If the refractory material used possesses a fusion point or softening range higher than the maximum temperature to which they are exposed, it would in most instances be desirable that they should be non-conductors of heat, for radiation losses would then be at a minimum. More often the prevailing temperatures approach and sometimes exceed that at which fusion or softening occurs. In those cases it is necessary to encourage radiation from the surface farthest removed from the heated surface, in order to cause a steep temperature gradient from the heated to the cooler face. In special cases cooling devices are necessary to prevent the rapid destruction of the material employed. Good conductivity for heat is most desirable where the material is used to form walls which transmit heat from the burning fuel to the contained charge which is being heated. The melting of steel in crucibles, the coking of coal and the distillation of zinc are instances where a refractory material with good heat conductivity is required.

These physical characteristics of refractory materials determine in large measure their suitability or otherwise for particular duties. Owing to the complex nature of most of the materials used in practice their properties are not those of the simple minerals of which they are composed, but the resultant of variations which are sometimes of opposite sign and are always varying at different rates. The relative size of the grains employed, the extent of the surface exposed by the more resistant constituents to the others used as bond or matrix, are most important factors in contributing to the ability of the material to perform useful service. Another point of some importance is the influence of mass in promoting or retarding inversions. Some of these inversions take place almost instantly once the critical temperature has been reached, but with others marked hysteresis occurs. Porosity must always occur when the refractory material is composed of more than one constituent, and where their chief volume changes are dissimilar or occur at different temperatures. Little is known of the effect of porosity on the properties of refractory materials. That the pores encourage the deposition of extraneous substances in the interior of the bricks, and that they render the structure permeable to gases, is of course obvious.

The stresses caused by temperature changes are due to the volume changes which take place during heating. If the refractory material happens to be a good conductor of heat these are not serious, unless one face is rapidly heated and the distortion produced exceeds the tenacity of the material. The remedy available is to avoid rapid temperature changes, and whenever possible to raise the temperature of the material during the burning stage of manufacture well above that at which the inversion to which the principal volume change should take place, and to hold it at that temperature long enough for the inversion to be completed. The spalling of magnesite bricks which sometimes occurs has been thus explained, and it is certain that the excessive expansion of silica bricks would be avoided if the manufacturer could ensure the completion of the quartz-tridymite inversion during burning. Despite the considerable advances in our knowledge of the inversions of silica made recently, their bearing on the problems that face the manufacturer are not yet sufficiently clear.

Advances in the art of metallurgy are largely conditioned by the nature of the refractory materials available. The manufacture of these materials is based almost entirely on empirical rules and the experience of the men employed. Such rules are the result of experiences gained during a century or more by a rude process of trial and error, but where there were only very inadequate means of correlation. The methods employed to-day represent the survival of the fittest by the searching test of commercial success, but it by no means follows that they represent the best attainable. Further progress, if made at all, can only be slow and uncertain, and by consent it is now admitted that only by adequate and well-directed scientific research can such progress be accelerated. The first step, and in all probability the one easiest to take, would be to prepare specifications for the most important refractory products expressed in terms capable of precise measurement or description, basing the specification on the best current practice. But specifications at their best only serve to stereotype the best current practice of their day. These specifications should be the starting point of systematic research which should cover, not only the problems that occur during manufacture, but the occurrence in nature and characteristics of the raw materials. Their concentration and purification, proximate and ultimate analysis, mineralogical description and thermal analysis are all points on which additions to our present knowledge would be of great value. But the refractory materials are so complex, and the problems involved are so difficult of direct attack, that any contributions to our knowledge of the properties of the pure minerals, or of the impure aggregates which are used in practice, would be welcomed even if their immediate application did not happen to be possible.

In connection with this subject, we may suitably quote a suggestion made by Dr. E. F. Roeber, editor of *Metallurgical and Chemical Engineering*, in the issue of that journal for April 15. In writing of refractories he points out that silicate of alumina when pure is an excellent material. The usual impurities, which are fusible, are Fe_2O_3, CaO, Na_2O, and K_2O; as these are soluble in dilute hydrochloric acid, he suggests that fire-clay should be leached and washed for the removal of these impurities. The methods of leaching and washing on a large scale have been perfected of recent years, and probably an installation on the Dorr system would be applicable. As Dr. Roeber mentions, the slight gelatinization of the silica by the acid would tend to increase the binding quality.

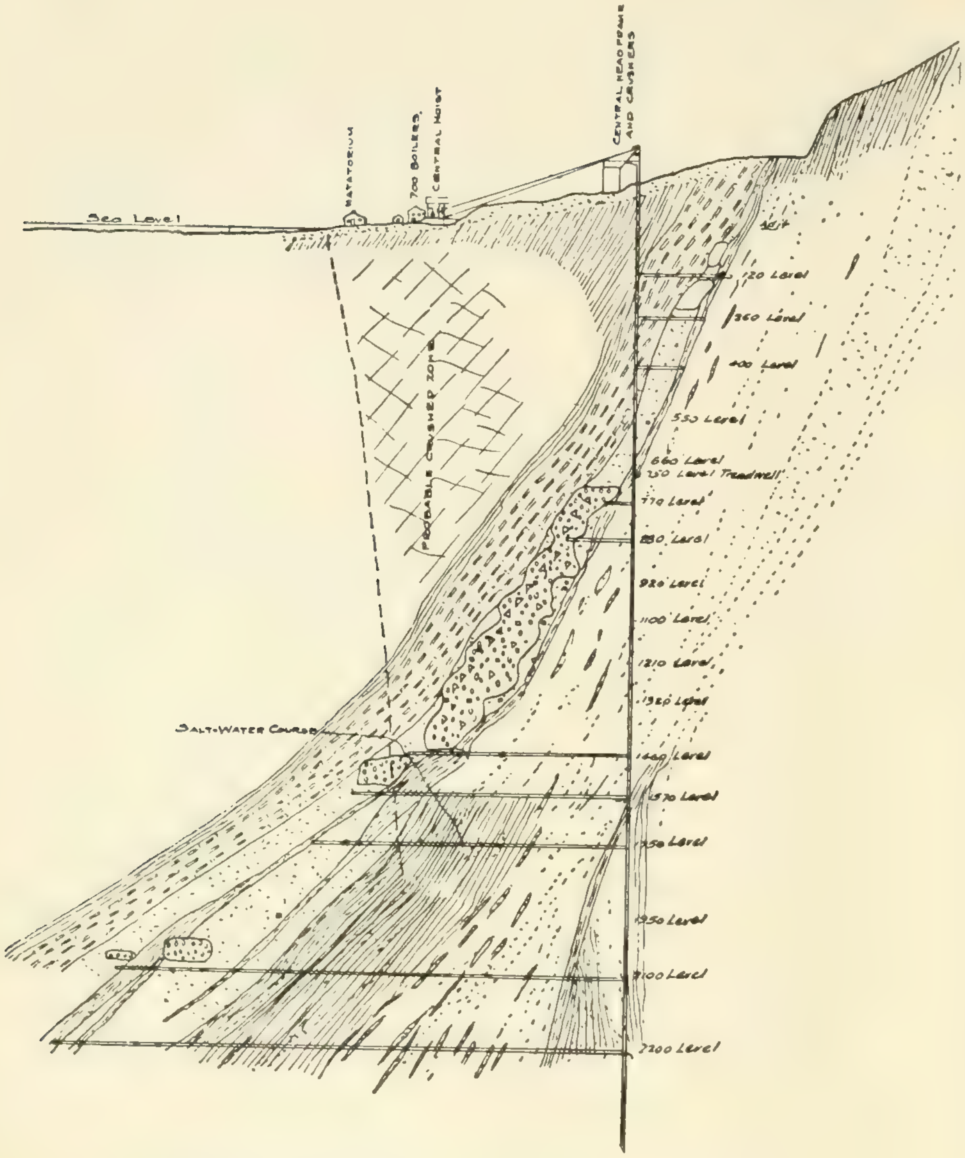
THE ALASKA TREADWELL DISASTER.

We have in a previous issue referred to the flooding of the Treadwell, 700 Ft., and Mexican mines on Douglas Island, Alaska, and the presumed loss of valuable ore reserves. Very little information has been officially published either in America or in this country. Unfortunately the issue of the *Mining and Scientific Press* for February 10 containing the reasons for expecting such a calamity failed to dodge the U-boats in its passage hither. We have since received a few copies, but the bulk of readers have not seen this article, and for their benefit we make liberal extracts herewith.

The rocks enclosing the ore-bodies or adjacent to them are greenstone, slate, and soda-syenite. These rocks, when large excavations are made in them, generally stand fairly well without support. Square-set timbering was prohibitive because of the cost, and the shrinkage method followed by filling with waste-rock from the surface was not undertaken for a similar reason. The system adopted can be outlined thus: The opening of levels from the shafts, the removal of the ore by overhand stoping, and the leaving of pillars of ore, both vertical and flat, to support the walls and the back of each stope. The vertical pillars, reaching from wall to wall, were left at intervals of 100 ft., measuring from centre to centre. The flat, or sheet-pillars, were horizontal or nearly so. When a stope was being cut, the miners stood on broken ore, only enough being withdrawn at the level below to keep the men within reach of the back, which was arched to reduce the tendency to cave. Ore was stoped to a maximum width of 250 ft., and in places was removed for a width of 160 ft. along a horizontal distance of 300 ft. The shape and size of a stope was controlled to a great extent by the value of the ore, and the mining stopped when the ore no longer yielded a profit. Unfortunately, when the ore was drawn from the stopes the excavations were not filled with waste. As a natural result an enormous pressure gradually developed on the hanging-wall side of the stopes, and this pressure became concentrated upon the pillars left to support the ground. During the last five or six years this hanging-wall pressure has become increasingly evident, and numerous caves have occurred in the various stopes, some of them of a disastrous nature. Not only was the immediate neighbourhood of the caving badly shaken, but the terrific concussions, known alternatively as "air-blasts," or "rock-bursts" caused damage at a distance, and frequently made themselves unpleasantly manifest at the surface. Some of the earlier caves proved to be rather an advantage than otherwise, as a lot of waste rock from the walls and from the surface fell into the open workings, filling some of them more or less completely, and thus ensuring against further serious caves at that locality. But where this broken filling did not break down into lower stopes the caving continued from time to time with increasing and alarming frequency.

These repeated caves in the underground workings began to show their effects with increasing distinctness at the surface, where a number of cracks developed. These became more pronounced as time went on, and an alarming subsidence of the ground became noticeable near the boundary between the Alaska Treadwell and the 700 Ft. mines. On July 27, 1916, a large crack was found in the north wall of the central shaft-house, and other evidences of disturbance began to be observed in various structures at the surface. Numerous cracks appeared in a concrete retaining-wall of the 700 ft. mill. Subsidence continued, and on August 29, the line-shafting of the mill had separated over two inches. The foundations of the buildings and machinery settled, cracks opened and closed in the floors, and other evidences of subsidence became numerous during the summer of 1916. That some of these cracks appearing at the surface extended to points far below was proved by one developed 50 ft. east of the Treadwell shaft. This crack was in greenstone and was 4 or 5 inches wide. But the most significant evidences of movement were to be seen on the various levels of the mine near the Treadwell shaft and for some distance from it. Workings caved, and some places were rendered inaccessible. The 750 ft. level was the scene of disastrous caves, and for 100 ft. from the Treadwell shaft all drifts except one were blocked. Underground, disturbances took place as low as the 1,600 ft. level, and cracks appeared in the 1,750 ft. level, so that it will be seen that the movement of ground was by no means confined to the region of the upper workings of the mine.

The most important matter in connection with this



TRANSVERSE SECTION OF TREADWELL ORE-BODY.

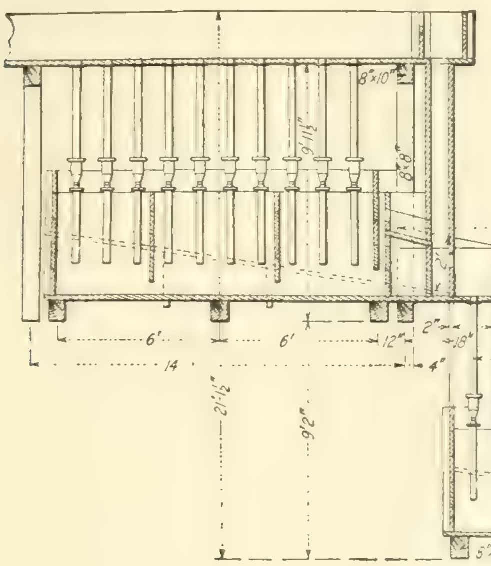
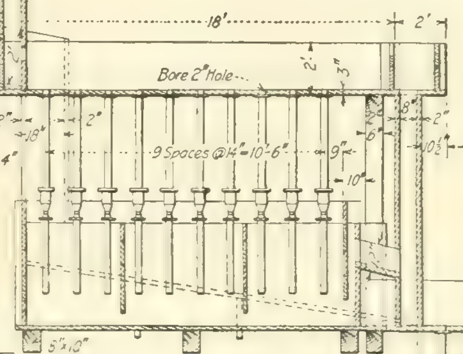
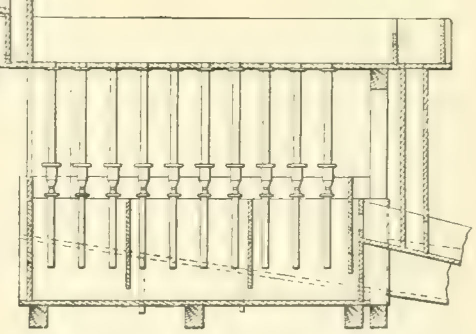
caving was the well-founded fear that the disturbance had not been confined to the area about the Treadwell and 700 Ft. end-line, but had extended north-eastward into the hanging-wall region, and underneath the water of Gastineau channel. The caves in the mine are the direct result of mining millions of tons of ore in large blocks while leaving insufficient support in the form of vertical and horizontal pillars. Over 340,000,000 cubic feet of rock has been excavated. This naturally has resulted in a general subsidence over a large area and the formation of an intricate system of fissures on the hanging-wall side of the ore deposits. At the time of writing it seemed probable that these cracks would extend upward to the bottom of Gastineau channel, and further movement on the planes of these fissures were recognized as promising calamitous consequences. Salt-water had made its appearance in the workings at a number of places. Natural fissures that have been in existence for a long period are usually filled with clay or some other mineral that may have been deposited from solution, sealing the crack and rendering it water-tight; not so, however, a crack recently made, such as those resulting from conditions due to causes above described. Cracks of this description are likely to afford free passage to water and if they become numerous, under the hydrostatic head that would develop in the lower levels—1,400 to 1,700 ft.—the water would be likely to enter the mine at a rapid rate and under conditions that probably could not be controlled.

This prognostication was verified shortly after the article was written. The accompanying illustration shows how the ore-body passes under Gastineau Channel. It is clear that as the water has risen in the mines to the level of the channel the whole of the workings are lost. At present the chances of saving the mines seem remote. Possibly something could be done by cross-cutting from the Ready Bullion, which is farther away and is not affected by this flooding.

Fairlie's Silver-Cobalt Process.—In the *Canadian Mining Journal* for March 1, R. B. Watson described a new process, used at the Cobalt Reduction Company's plant, and devised by M. F. Fairlie, for making high-grade ore and rich concentrate more amenable to cyanide action. The process consists of treating the material with chlorine added as bleaching powder, which has the effect of oxidizing the complex refractory argentiferous minerals. At the new plant, the low-grade ore is concentrated in the usual way on tables, and the slime sent direct to the cyanide department. The table concentrate is re-concentrated on tables and brought up to 2,000 oz. per ton, while the tailing from this treatment is sent to the cyanide plant with the slime. The rich concentrate, together with the high-grade ore, is then ground wet for 24 hours in a tube-mill equipped with iron linings and balls. To this charge is added, toward the end of the operation, 2% of bleaching powder. The charge from the tube-mill goes to a Dorr classifier, where the coarse material, including the metallics from the ore, is removed. The pulp, after being well washed, is de-watered by an Oliver filter, and treatment by a strong cyanide solution follows. The final residue, after filtration on another Oliver filter, can be readily marketed for its cobalt and silver content. The silver-bearing solution is precipitated by sodium sulphide, the resulting precipitate being desulphurized in a small tube-mill by the aid of metallic aluminium and a caustic soda solution. This method of precipitation was first installed in Cobalt at the Nipissing, and was described in our issues of October 1913 and December 1916. The oversize raked out by the classifier is given a partial roast on the hearth of the furnace to eliminate part of the arsenic and is then melted down to bullion. The small amount of speiss and slag is returned to the tube-mill with the next charge. By this simple but ingenious process, the company, which was formerly one of the largest shippers of ore and concentrate in the district, is enabled to market practically its entire production in the form of fine silver bars.

Toluene in Petroleum.—At the meeting of the Institution of Petroleum Technologists held on May 15, S. E. Bowrey read a paper on the occurrence of toluene and other aromatic compounds in petroleum. He pointed out that the production of these compounds by "cracking" petroleum is very wasteful, seeing that a large proportion of the petroleum is converted into useless materials. He therefore recommends the extraction of such amounts as naturally occur in petroleum as a more economic course. The author discusses in detail the methods for determining the amount present, dealing particularly with the liquid sulphurous acid method.

Crowfoot's Flotation Machine.—In the *Engineering and Mining Journal* for April 14, Arthur Crowfoot describes a flotation machine erected at the Arizona Copper Co.'s concentration plant. The air required for frothing is introduced on the same principle as that used in the hydraulic air-compressor, namely, by entraining air in the pulp by letting it fall through pipes. In the plant, no power or porous medium is required, but plenty of head-room is necessary for the succession of falls from one cell to another. The accompanying illustration sufficiently describes the design. It will be seen that the pulp passes from narrow launders down pipes which discharge it below the surface of the water in the cells; the entrapped air releases in the cell, and as it rises carries the sulphide particles upward. This plant is known as the "A.C." flotation machine.

THE "A.C." FLOTATION MACHINE.

Drills for Metal Mining.—The *Engineering and Mining Journal* for May 12 publishes an article on drill bits and drill steel for metal mining, by G. H. Gilman, of the Sullivan Machinery Co. The author discusses the various shapes, the material used in their manufacture, and the methods of tempering.

Methods of Mining Big Ore-bodies.—The *Mining and Scientific Press* for April 21 and 28 contains articles by Robert A. Kinzie, lately manager of the Alaska Treadwell group, on the mining of big ore-bodies. He discusses methods applicable to the ore at Treadwell and on the mainland behind Juneau at the Perseverance, Gastineau, and Ebner mines.

Gold Dredging in Tierra del Fuego.—In the *Engineering and Mining Journal* for April 24, Lyman Chatfield gives a short outline of dredging operations.

Classification.—In the *Mining and Scientific Press* for April 28, M. Hyde describes a method and plant for de-sliming and subsequent classification of sand.

Percentage of Oil in Flotation.—In connection with the Minerals Separation judgment relative to the use of less than 1% of oil, H. A. Megraw writes in the *Engineering and Mining Journal* for May 5 detailing the statements of various mining companies that more than 1% is as effective as less than this amount, and even more so. Minerals Separation, though winning the patent suit against J. M. Hyde on the latter's patent as used at the Butte & Superior, is now having to bring an action against this company for the recovery of royalties. Much technical evidence is being adduced by the defendant company to show that there are advantages in using over 1% of oil.

Electric Iron Smelting.—J. O. Boving writes on the electric smelting of iron ores in the *Iron & Coal Trades Review* for May 25.

Tungsten.—At the meeting of the Cornish Institute of Engineers held on June 2, H. W. Hutchin presented a paper on tungsten, discussing its compounds, ores, metallurgy, and methods of assay. We intend to print the greater part of this paper in a subsequent issue.

Desilverizing.—The May *Bulletin* of the American Institute of Mining Engineers contains a paper by W. E. Newnam, superintendent of the St. Louis Smelting & Refining Co., describing a recent improvement in the Pattinson desilverizing process. The novelty consists in mechanical improvements, suggested by Stephen Tredinnick, in the Luce & Rozan modification of the process. A plant has been erected for the purpose of further refining lead bullion that has already been treated by the Parkes process, the main object being to reduce the bismuth content so as to make the lead suitable for corroding, and in the same operation to produce a residual lead high enough in bismuth to warrant refining by the Betts electrolytic method.

Lead Smelting in Ontario.—In the April *Bulletin* of the American Institute of Mining Engineers, W. E. Newnam describes lead mines on Chats Island, 30 miles west of Ottawa, where high-grade galena concentrate is produced. The author erected his mechanical ore-hearth to smelt the galena. This ore-hearth was described in our issue of November 1915. Results have shown that ore or concentrate as low as 68% lead can be effectively treated in this hearth at a low cost.

Antimony.—The *Queensland Government Mining Journal* for February contains a paper by B. Dunstan on the antimony deposits of Queensland and other countries of the world, with notes on ores and treatment.

Antimony Metallurgy. — In *Metallurgical and Chemical Engineering* for April 15, J. A. De Cew discusses processes and furnaces for treating low-grade antimony ores, by volatilization of the stibnite as oxide. The difficulty of collecting the fume is mentioned, and the application of the Cottrell electrostatic precipitation method is described.

Electrolytic Zinc Plants in the United States.

Company.	Location of plant.	Daily spelter capacity.	Remarks.
American Smelting & Refining Co.	Murray, Utah	Experimental	Operated in 1916.
Anaconda Copper Mining Co.	Anaconda, Mont.	25 tons.	Operated in 1915-16; now idle.
Do.	Great Falls, Mont.	200 tons	Under construction; 100 tons in operation at end of 1916.
Basin Salvage Co.	Basin, Mont.	Experimental	Under construction.
Bully Hill Copper Co.	Bully Hill, Cal.	Experimental	Operated in 1915-16.
Electrolytic Zinc Co.	Baltimore, Md.	10 tons.	Operated in 1916.
Judge Mining & Smelting Co.	Park City, Utah	15 tons	Completed March, 1917.
Mammoth Copper Mining Co.	Kennett, Cal.	25 tons	Will be completed by May, 1917.
Reed Zinc Co.	Palo Alto, Cal.	Experimental	Operated in 1914-15; idle in 1916.
River Smelting & Refining Co.	Keokuk, Iowa	10 tons	Operated in 1916.
Western Metals Co.	Georgetown, Colo.	Ore capacity, 100 tons	Malm process; under construction.

Electrolytic Zinc.—A pamphlet published by the United States Geological Survey, compiled by C. E. Siebenthal, relating to the output of zinc in the United States during 1916, contains a paragraph on the production of electrolytic zinc. Mr. Siebenthal reports that the total capacity at the end of 1916 was not as great as the original estimate of the Survey, and, instead of 60,000 tons, the actual rate of output was 40,000 tons per year. This fact was due to the delay in completing several plants. It is stated that when the plants now under construction are at work the yearly capacity will be 85,000 tons. The actual output of electrolytic zinc during 1916 was 12,916 short tons, of which 1,800 tons was produced by refining prime western spelter, 887 tons was refined from scrap and dross, and 10,229 tons was produced direct from ores by leaching and electro-deposition. The total production of zinc in the United States during 1916 was 667,456 short tons. The accompanying table gives particulars of the electrolytic zinc plants in the United States. In writing of electrolytic zinc in North America, it is desirable to mention also that one of the most important plants is at Trail, British Columbia. This was described in our issue of February last.

Refining Zinc. — The *Engineering and Mining Journal* for May 5 shortly describes the refining furnace introduced by C. A. H. de Saulles for refining crude zinc, and used by the United States Zinc Co., the American Spelter Corporation, and the Western Spelter Company.

Zinc - Works Pottery. — In *Metallurgical and Chemical Engineering* for May 1, E. M. Johnson describes processes and plant for preparing clay and making retorts for zinc smelting.

Sulphuric Acid.—The *Engineering and Mining Journal* for April 21 quotes a paper by A. M. Fairlie, read before the American Chemical Society, describing his method of testing the gases in sulphuric acid chambers, and of regulating the relative amounts of the SO_2 and nitrous fume introduced. This method is used at the Tennessee Copper Company's sulphuric acid plant.

Aluminium Dust.—The *Mining and Scientific Press* for April 14 contains an article by P. H. Crawford on tests at the Divisadero mine, Salvador, on the precipitation of gold and silver from cyanide solutions by means of aluminium dust.

Electro-Cyanide Process. — *Metallurgical and Chemical Engineering* for April 15 describes Sill's electro cyanide-amalgamation process for treating gold ores in pans.

New Methods of Analysing Limestone and Ammonium Salts.—Dr. James Moir gives a paper on this subject in the February issue of the *Journal* of the Chemical, Metallurgical, & Mining Society of South Africa.

Potash in Nebraska. — In the *Engineering and Mining Journal* for May 5, R. P. Crawford describes the operations recently started for utilizing the potash and soda contained in lakes in Nebraska. Five companies are at present at work. The brine is evaporated, and the salt produced contains 27% K_2O as carbonate and sulphate, with about an equal amount of Na_2O as carbonate, chloride, and sulphate. The crude salt is shipped east.

Graphite.—In the *Engineering and Mining Journal* for April 21, Irving Herr describes the graphite deposits in Clay County, Alabama. He gives details of the methods of mining the deposits and of producing concentrate.

Origin of Zinc Deposits.—The May *Bulletin* of the American Institute of Mining Engineers contains a paper by F. L. Nason on the origin of the American zinc deposits. He draws on the evidence provided by his own experience and generally supports W. P. Jenney and C. E. Siebenthal in their theories that the zinc blende has been precipitated from ascending alkaline-saline sulphuretted waters.

Osmotic Pressure.—The Faraday Society's Symposium on this subject was held on May 1.

RECENT PATENTS

1,000 of 1916 (105,772). A. A. Lockwood, London. In depositing copper electrolytically from ore, first agitating the pulp, then leading the pulp into a vessel containing electrodes from which a current passes through the pulp, the ore being kept in suspension all the time by a jet of air.

9,087 of 1916 (105,830). C. O. Griffith, Wormit, Fife. Producing pure sulphides of metals such as zinc and antimony by electrolytically treating electrodes of the metal, with sulphur in contact with the cathode, and using ammonium chloride as electrolyte.

4,780 of 1916 (105,255). P. Marino, London. In the process of electrolytically coating metal surfaces with zinc, adding to the electrolyte glycero-sulphuric acid, boric acid, and a halogenated derivative of lactic acid.

9,714 of 1916 (100,848). Chemische Fabrik Griesheim Elektron, Frankfort, Germany. For the purpose of adding silicon and magnesium to liquid iron or steel as deoxidizers, preparing a mixture of ferro-silicon and an alloy of magnesium with aluminium or nickel.

5,854 of 1916 (105,627). H. L. Sulman, E. Edser, and Minerals Separation Limited, London. In floating such minerals as carbonate of copper from a gangue such as a silicious gangue, mixing the ore with small portions of a frothing agent such as sodium oleate, together with paraffin, and agitating by the sub-aeration agitation-froth method.

6,659, 6,701, and 11,492 of 1916 (105,645, 105,646, and 105,853). Titanium Alloy Manufacturing Co., New York. A white pigment consisting of one quarter titanic acid and three quarters sulphate of lime.

NEW BOOKS

The Banket: A Study of the Auriferous Conglomerates of the Witwatersrand and the Associated Rocks. By Robert B. Young. Cloth, octavo, 140 pages, illustrated; price 8s. 6d. net. London: Gurney & Jackson.

The conglomerates responsible for the world's greatest goldfield are naturally worthy of close attention from the point of view of the geologist and mineralogist. Mining operations have provided unrivalled facilities for the investigation of the banket, and of these the geologist has not been slow to take advantage. Professor Young does not pretend to have treated his subject exhaustively. The banket constitutes a series of very ancient deposits, whose origin is still partly veiled by the mists of the past, and whose long and varied history is seen as yet but in glimpses here and there. Nevertheless, Professor Young places before us a very complete petrographic account of these deposits and their associates, and then in the light of his harvest of facts, he modestly discusses the origin of the gold, a problem which in practice implies the origin and history of the parent rock itself. A noteworthy feature of the book, and one which adds materially to its value, lies in the wealth and beauty of the 28 plates, consisting mostly of photo-micrographs, with which it is illustrated.

As the sediments of the Rand have been derived from the waste of the rocks of the Swaziland System, it is of interest to notice that those rocks contain gold in quartz veins and impregnations, like the auriferous schists of West Australia and South India. The constituents of the banket are described in great detail, and are divided into two groups: (1) Allogenic, those of detrital origin, whether as pebbles or matrix, and (2) Authigenic, those that have been introduced into the rock from without, or recrystallization of the allogenic constituents; in the latter category gold is placed.

The chief or otherwise noteworthy constituents are dealt with in the following order:

(1) *Allogenic*: Pebbles: vein quartz, quartzite, quartz-porphyry, quartz-tourmaline, schist (very rare); Matrix: quartz, zircon, chromite, tourmaline, diamond, iridosmine and platinum.

(2) *Authigenic:* Secondary quartz, chloritoid and chlorite, muscovite and sericite, tourmaline, rutile; Matrix: calcite, dolomite, carbon, pyrite, pyrrhotite, other metallic sulphides, gold.

Comparison of the pebbles with the corresponding rocks of the Swaziland System indicates that, as early as Witwatersrand time, these rocks had assumed in the main their present characters. The scarcity of schist shows that conditions of denudation and deposition were such that only the hardest individuals, generally quartzose, were permitted to survive. The flattened muffin-like shape of the pebbles seems to imply that the formation was originally a marine or estuarine shingle.

The most striking feature in the list of allogenic minerals is the absence of magnetite and ilmenite, minerals that are now present in abundance in the sands derived from the Swaziland rocks. It is suggested that they were originally present, and are now represented as pyrite and rutile. The so-called "pyrite pebbles" are, of course, pseudomorphs after quartz, and in the case of the smaller grains perhaps after iron ores.

Among the complicated mineral changes, involving much metasomatism, that the banket has suffered, Professor Young lays stress on the following: (*a*) solution and reprecipitation of the gold, (*b*) conversion of the iron oxides into pyrite by sulphuretted waters, accompanied by the formation of rutile, (*c*) solution and reprecipitation of a portion of the pyrite, (*d*) formation of chloritoid, sericite, and chlorite, at the expense of allogenic argillaceous and felspathic material, (*e*) addition of metallic sulphides, chlorite, sericite, calcite, and carbonaceous matter derived from later igneous rocks during their cooling and subsequent alteration.

With regard to the origin of the gold, Professor Young is inclined, on the evidence at present available, to accept the placer theory, the modern form of which involves solution of the detrital gold followed by redeposition in intimate association with pyrite. The placer theory is thus reconciled with those features of the mode of occurrence of the gold that have been held to support the infiltration theory. Moreover, it explains quite satisfactorily the gold in the associated pyritic quartzite, where it occurs in bands that were originally auriferous black sands.

The author is to be congratulated on having written a highly interesting account of the banket, easily intelligible to anyone with an elementary knowledge of geology. His book should stimulate other workers in the same field to carry on the investigations. The reviewer would suggest that future researches should include careful and detailed chemical analyses of the rocks and minerals concerned, and that the matrix in particular should be attacked by methods of quantitative mineral analysis and elutriation.

ARTHUR HOLMES.

The Microscopic Determination of the Opaque Minerals. By Dr. J. Murdoch. Cloth, octavo, 170 pages, price 9s. 6d. New York: John Wiley & Sons; London: Chapman & Hall.

The scope of this excellent little pioneer work is sufficiently indicated by its title. The author states that "the primary object has been the production of a practical and simple scheme of mineral identification, and accordingly only those lines of investigation have been pursued which contributed directly toward this end." He is to be congratulated on having produced an eminently practical little volume containing much new information relative to the determination of the different ore minerals in polished sections by the aid of the microscope. The work embodies many of the results of the studies in the identification of ore minerals in polished sections that were found to be essential preliminaries for the investigation of the secondary enrichment phenomena presented by ore-bodies, a special scientific investigation that is now being conducted in the United States. It will be found a thoroughly useful and practical manual for the microscopic identification of ore minerals, and is a valuable contribution to the literature of determinative mineralogy. As such it should find a place in the library of any one interested in the problems of ore occurrence.

One particularly interesting conclusion that has been drawn from the results of careful microscopic investigation of a host of samples from many localities, and one which should be seriously taken to heart by both mining and metallurgical engineers, is that "the mineralogy of the sulphides needs complete revision," a conclusion which the writer of this review has also reached independently though on entirely different grounds. The systematic examination of the ore minerals by the aid of the reflecting microscope is a mineralogical method of research that is as yet only in its infancy, and it is to be hoped that the author will receive such encouragement from the reception of this first edition of his book as will prompt him to produce something larger and more complete at a later date. The absence of photo-micrographs, except for a coloured frontispiece, is a feature in a work of this kind that makes it a little disappointing, and is one where there is room for improvement in any subsequent edition.

The author has introduced a new term for this kind of geologic investigation, namely "mineralography." On this point the reviewer must seriously join issue with him as to the propriety of adding to the already overweighted burden of geological nomenclature. It ill befits the temple of science, nor does it assist in the advancement of natural knowledge, to emulate the subterfuges of the biscuit manufacturer or the sweetstuff vendor, and to coin new terms when they are not required as an aid to thought or scientific advance. No new or specially individualized idea is embodied in the examination of opaque minerals through the tube of a microscope. Admitting the importance and value of this method of research, the argument used by the author that, because it "is now established as a definite branch of geologic investigation," "it merits a designation of its own" is as fallacious as to imagine that the science of botany would be aided by christening every branch of a growing tree with a new name, nor will the great science of mineralogy be assisted by giving a long name to the new little twig.

Metallography is not the microscopic study of metals and alloys, as asserted by the author in attempting to justify the term "mineralography," but something much more comprehensive, as will be apparent to anyone who cares to turn up an elementary treatise on the subject, nor is petrography, rightly understood, or as the framers of the term meant it, the mere microscopic study of rocks, even if the word "commonly implies" this, while the propriety of coining new and redundant terms on "common implications," and, be it said, common misunderstandings, is a more than questionable procedure that would be better abolished from true scientific thought and literature once and for all. The reviewer hopes that the author will reconsider the question of thrusting a new and quite unnecessary term on the long-suffering students of geology, in the light of the example of the nomenclature of petrography, which, like a modern tower of Babel, effectively smothers and conceals many of the simpler natural features and relationships of the rocks on which it is built.

W. H. GOODCHILD.

A Pocket Hand-book of Minerals. By G. Montague Butler. Pocket size, leather cover, 320 pages, and tables; price 12s. 6d. New York: John Wiley & Sons; London: Chapman & Hall.

This is the second edition of a book designed for use in the field or class-room, with little reference to chemical tests. The author is professor of mineralogy in the University of Arizona.

Valuation, Depreciation, and the Rate-Base. By C. E. Grunsky. Cloth, octavo, 390 pages; price 18s. 6d. New York: John Wiley & Sons; London: Chapman & Hall.

This is a book that will be helpful to mining companies which are confronted with the problem of reorganizing their methods of allowing for depreciation of assets and amortization of capital. A review will appear in a latter issue.

Bucket-Dredging for Tin in the Federated Malay States. By Harry D. Griffiths. Cloth, quarto, 40 pages; price 5s. London: *The Mining Magazine*.

This is a reprint of the articles published in the Magazine in December, January, February, and March last. The auther discusses the design of dredges, gives the results of operations, and demonstrates future possibilities.

COMPANY REPORTS

Golden Horse-Shoe Estates.—This company was formed in 1894 to acquire property at Kalgoorlie, West Australia, and milling commenced in 1899. For eleven years the yield and dividends were maintained at a high level, but in 1910 the extent of the reserves and the gold content of the ore began to fall, and since then the dividends have been comparatively small and sometimes non-existent. The report for 1916 shows that operations have been seriously restricted by shortage of labour, and the amount of ore treated was much less than normal. The amount treated was 179,340 long tons, as compared with 243,564 tons in 1915 and 284,496 tons in 1914. The yield of gold was 89,025 oz., worth £380,659, and the net profit was £84,535, out of which £75,000 was distributed as dividend, at the rate of 5% on the capital, £1,500,000. J. W. Sutherland, the manager, reports the ore reserve at 709,819 tons averaging 9·5 dwt. per ton, as compared with 704,359 tons averaging 9·2 dwt. a year ago. The No. 4 lode contains the best ore, and contributes 217,339 tons averaging 13¼ dwt. to the reserve.

Cock's Pioneer Gold & Tin Mines.—This company was formed in Melbourne in 1913 to acquire an alluvial property in the Beechworth district, north-east Victoria. The control is with the Baillieu group, and A. H. P. Moline is manager. The gravel contains both gold and cassiterite, and it is treated by pump-dredge. The report for the half-year ended November 30 last shows that 324,000 cubic yards of ground was treated, for a yield 2,861 oz. of gold and 38¾ tons of tin concentrate. The yield per yard was 8·27d. in gold and 0·268 lb. in tin concentrate. The accounts show an income of £11,259 from gold and £4,630 from tin, making a total of £15,889. The net profit was £3,812, out of which £1,197 has been written off for depreciation, and the rest placed to equalization of dividend reserve. We shall be publishing shortly an article by Mr. Moline describing this hydraulic practice.

Mount Boppy Gold.—This company was formed by John Taylor & Sons in 1899 to acquire a gold mine in the Cobar district, New South Wales. Mining operations were uniformly successful from 1902 to 1911. Subsequently the arrival at the sulphide zone, the alternations of drought and superabundant water, and finally the impoverishment of ore in depth have caused a succession of troubles, though dividends on a restricted scale continued until 1915. The report for the year 1916 shows that 72,420 tons of ore was raised for a yield of gold worth £85,837, as compared with 79,526 tons and £119,589 the year before. The result of the year's work was a loss of £17,313. Scarcity of labour, unusual rainfall, and fall in the grade of ore have combined to bring about this result. It has been decided to suspend mining and milling until conditions improve. In the meantime it is intended to sink a new shaft that will be out of the sphere of influence of the heavy rains. This will release 100,000 tons of ore of good grade in the vicinity of the present main shaft. In addition to this ore, there is a reserve calculated at 154,000 tons. The time required to sink the new shaft and prepare the mine for resumption of work is estimated at twelve months.

Lonely Reef.—This company belongs to the Lewis & Marks group, and was formed in 1910 to acquire partly developed gold mines situated 55 miles north of Bulawayo, Rhodesia. The lode is strong and persistent, and the yields have been substantial. The report for 1916 shows that 59,240 tons of ore was treated for a yield of gold worth £175,567, being a return of just over 14 dwt. per ton. The working profit was £68,187, out of which £18,743 has been reserved for taxes, and £9,328 written off for depreciation. The shareholders received £42,006, the dividend being 20%. The levels from the 13th to the 17th have been in excellent ore, and the reserve is estimated at 145,309 tons averaging 20 dwt., as compared with 157,279 tons averaging 15 dwt. the year before. C. B. Kingston is consulting engineer, and S. H. Boright is manager.

Namaqua Copper.—This company was formed in 1887 to acquire the Tweefontein and other copper mines at Concordia, Namaquoland, in the western part of the Cape Province, South Africa. The property is near that of the Cape Copper Co. Of recent years the operations have been restricted owing to disappointing development. The report for 1916 shows that 20,024 tons of ore averaging about 5·8% copper, and 13,923 tons of briquettes made of slime and old jig tailing, were smelted for a production of matte and bottoms containing 1,680 tons of copper, a decrease of 99 tons as compared with 1915. Development has failed to disclose any important further supply of ore, and the reserve at December 31 was estimated at 51,264 tons averaging about 5¾% copper, as compared with 66,731 tons a year ago. The accounts show an income of £249,110 from the sale of products and a net profit of £64,960, out of which £47,165 has been paid as dividend, at the rate of 25%. William Rich is managing director.

Pena Copper Mines.—This company was formed in London in 1900 to acquire a copper and sulphur mine in the south of Spain that had, for two or three years previously, been worked by a Belgian company. Small dividends were paid from 1903 to 1906, but subsequently conditions became less favourable. About six years ago the contract with the Rio Tinto company in connection with railway transport to the coast was terminated, and an independent branch railway to the mine was constructed. During the period of building, deliveries of ore were suspended. The railway was opened in 1914, and since that time the position of the company has steadily improved. The report for 1916 shows that 161,283 tons of ore was raised, as compared with 122,120 tons in 1915; of this amount 53,729 tons was added to the leaching floors, and 107,554 tons was placed for export. The deliveries during the year were 30,766 tons of cupreous ore, 67,527 tons of non-cupreous ore, and 112,145 tons of washed ore. The yield of copper precipitate contained 598 tons of fine copper. The accounts show a net profit of £64,933, out of which £31,248 was paid as dividend, being at the rate of 7½%. The remainder was added to the balance in hand, which now stands at £59,837.

Kramat Pulai.—This company was formed in 1907 to acquire alluvial tin property at Pulai, in the Kinta district of Perak, Federated Malay States. B. W. Thunder is general manager. The capital is £100,000, and dividends averaging 10% per year have been paid since 1912. The report shows that 206 tons of tin concentrate was recovered, as compared with 292 tons the year before, the drop being due to exceptional floods and the breakdown of part of the plant consequent thereon. The produce sold for £20,971, and in addition £3,259 was received from tributers. The net profit was £10,731, out of which £10,000 has been distributed as dividend.

Ipoh Tin Dredging.—This company was formed in 1913 to acquire alluvial tin property in the Kinta valley, Perak, Federated Malay States, and since 1915 the management has been with the Borneo Company. Dredging started in September 1915. The report for the year 1916 shows that 697,850 cubic yards of ground was treated, for a yield of 250 tons of tin concentrate, selling for £27,029. The profit was £5,454, out of which £4,480, or 5%, was distributed as an interim dividend in May a year ago. L. G. Attenborough, the manager, states that the clayey nature of the ground caused much difficulty both as regards restriction of the yardage treated and from the point of view of extraction. The yield per yard was 0·8 lb. The percentage of recovery of the tin contained in the ground was estimated at 65%, but where the ground was free from clay the percentage was over 90%. The conditions caused unexpectedly great wear of the screen and buckets. The varying content of the ground is shown by the fact that the monthly averages of the yield ranged from 0·53 to 1·03 lb. A boring campaign has been conducted with the object of testing other portions of the property, and some other ground has been bought. The directors consider the reserves warrant the erection of a second dredge. The present returns from the mine are satisfactory and an interim dividend of 5% for 1917 has been declared.

Rayfield (Nigeria) Tin Fields.—This company was formed as the Rayfield Syndicate by Oliver Wethered in 1910, and was expanded in 1912 under its present name with a capital of £400,007. The present properties are the Top, Shen, and Delimi. The report for the 15 months ended December 31 shows that 843 tons of tin concentrate was won, and that 839 tons was sold, realizing £103,403. The net profit was £12,846, which was carried forward. The debentures have been reduced by £9,978, the amount outstanding being £34,995. At the meeting of shareholders, the manager, John M. Iles, spoke of the development of other properties at Delimi.

Jos Tin Areas (Nigeria).—This company was formed in 1910 to work alluvial tin properties near Naraguta, Nigeria. The work of the company is notable because it is the pioneer of bucket-dredging in Nigeria. Details of its performance were given by the manager, H. E. Nicholls, in a paper read before the Institution of Mining and Metallurgy. The report for the year ended July 31, 1916, shows that 301 tons of tin concentrate was produced, of which 132 tons was won by the dredge. During the previous year the dredge won 339 tons. The fall is due to the fact that the upper area was exhausted and the dredge had to cut its way through poor or barren ground in order to get the lower area. The accounts show an income of £37,629, and a net profit of £8,722, out of which £7,500 has been distributed as dividend, at the rate of 10 per cent.

Ex-Lands Nigeria.—This company was formed in 1912 by the Exploring Land & Minerals Co., a company previously identified with Rhodesia, for the purpose of acquiring alluvial tin properties in the South Bukeru district of Northern Nigeria. The report for 1916 shows that the output of tin concentrate was 404 tons, as compared with 388 tons during 1915. The accounts show credits of £41,813, and a net profit of £17,110, out of which £13,490 has been distributed as dividend, being at the rate of 10%.

Kaduna Syndicate.—This company was formed in 1910 to acquire alluvial tin properties in Nigeria. The first properties to be investigated were in the Kano district, but subsequently properties in the Arim district, 16 miles south-west of Bukeru, were acquired. Production started in 1912. Lake & Currie are the consulting engineers, and J. E. Snelus is manager. The report for the year ended October 30 last shows that 239 tons of tin concentrate was won, as compared with 216 tons the year before. The income from sales was £27,392, and the working profit was £9,787, of which £880 was applied to debenture redemption, £1,532 was written off capital expenditure, and £2,500 was placed to reserve. The shareholders received £3,513, the dividend being at the rate of 35%. The issued capital is £10,107, and there are £8,805 debentures.

West Rand Consolidated.—This company belongs to the Albu group, and was formed in 1903 to acquire a number of properties in the far west Rand. In 1907 the Violet mine and mill were bought, and in 1915 part of the property of the Lancaster West company was purchased. The property includes workings on the Botha or Main Reef, and on the Battery Reef to the south. Milling commenced in 1908. The only dividend so far distributed was one of 3¾% in 1909. The issued share capital is £2,004,424, and there are £364,840 debentures outstanding. The report for 1916 shows that 480,044 tons of ore was raised, of which 326,938 tons came from Main Reef stopes, 107,094 tons from Battery Reef stopes, and 46,012 tons from development. After the removal of 16% waste, 402,590 tons was sent to the mill. The yield of gold was 115,009 oz., or 5·7 dwt. per ton milled, worth £480,154, or 23s. 10d. per ton. The working cost was £394,177, or 19s. 7d. per ton. Other business brought a revenue of £22,052. Out of the balance of profit, £22,954 was paid as debenture interest, and the remainder was carried forward. The ore reserve is estimated at 1,600,000 tons averaging 6·1 dwt., and the partly developed ore at 404,000 tons averaging 8·3 dwt., the total being 2,004,000 tons averaging 6·5 dwt. These figures are 90,000 tons less and 0·4 dwt. greater than a year ago.

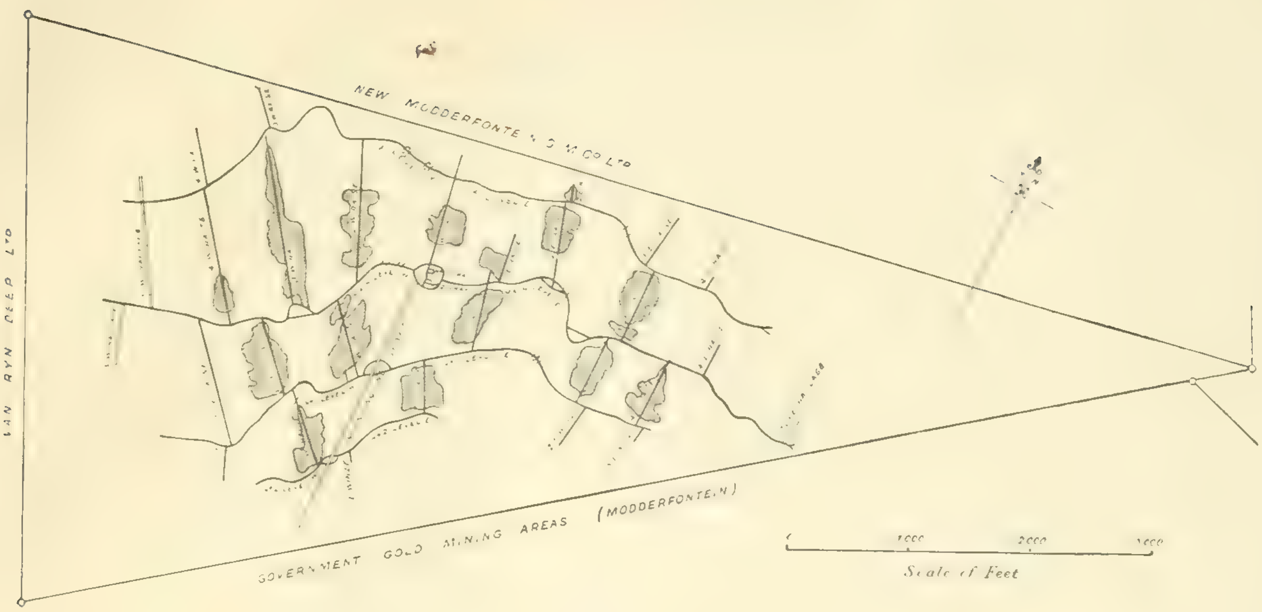
Consolidated Langlaagte.—This company belongs to the Barnato group, and was formed in 1902 to consolidate the Crœsus and Langlaagte Star, in the western part of the central Rand. Deep levels were acquired in 1908. The Crown Reef-Ferreira dyke upthrows the reefs, bringing the southern part 1,100 ft. nearer the surface, so that a new scheme for dealing with this part of the property had to be arranged. The mill was rebuilt in 1912, and now contains high-duty heavy stamps. The report for 1916 shows that about 12½% of the ore came from the older parts of the property and 87½% from the part south of the dyke. The total ore raised was 703,410 tons, and after the removal of 11% waste, 627,050 tons averaging 6·1 dwt. was sent to the mill. The yield of gold was 184,937 oz., worth £785,636, or 25s. per ton. The working cost was £505,975, or 16s. 1d. per ton, leaving a working profit of £279,661, or 8s. 11d. per ton. The shareholders received £213,750, being 22½%. The conditions at the mine were not as good as in 1915, owing to a gradually decreasing supply of suitable labour. For this reason the tonnage treated was below normal and the cost per ton advanced slightly. The quality of the ore exposed in development has been lower and stretches of unprofitable ground were encountered. The reserve at December 31 was calculated at 2,174,536 tons averaging 6·2 dwt. over 49 inches, comparing with 2,248,656 tons averaging 6·5 dwt. a year ago, and 2,220,707 tons averaging 6·9 dwt. two years ago. In order to maintain a profitable reserve, it will be necessary to increase the scale of development, and efforts are being made to secure additional labour supply for this purpose.

Witwatersrand Gold.—This company has belonged to the Barnato group since shortly after the Boer war. It was formed to acquire the Knight's property in the eastern Rand in 1886. In the early days the results were not good, but since 1905 excellent dividends have been distributed. Since 1910 attention has been devoted to the long narrow strip constituting a deep-level section. The report for 1916 shows that 581,929 tons of ore was raised, and after the rejection of 11½% waste, 515,000 tons averaging 6·23 dwt. was sent to the mill. The yield of gold was 153,534 oz., worth £652,568, or 25s. 4d. per ton. The working cost was £393,949 or 15s. 4d. per ton, leaving a working profit of £258,618, or 10s. per ton. The dividends absorbed £234,812, being at the rate of 50%. The ore reserve on December 31 was calculated at 1,462,100 tons averaging 6·4 dwt. as compared with 1,480,423 tons and 6·83 dwt. a year ago. The development of the southern section is making good progress, and it is noteworthy that the Main Reef contains profitable ore as well as the South Reef.

Knight Central.—This company was formed in 1895 to acquire a second deep below Knight's Deep, in the east Rand. The control was with Neumann's, and has now passed to the Central Mining. Milling commenced in 1909, and the first and only dividend was paid in 1910. The ground is intersected by the great Simmer dyke, and the development of the ground below it occasionally gives a brief encouragement. The report for 1916 shows that 321,575 tons of ore was raised and sent direct to the mill. The yield of gold was worth £337,798, or 20s. 11d. per ton, and the working cost £314,593, or 19s. 6d. per ton, leaving a working profit of £23,205, or 1s. 5d. per ton. Out of accumulated profit, £51,440 was spent on shaft-sinking, plant, and buildings. The ore reserve is estimated at 296,800 tons averaging 5·35 dwt., figures less by 109,600 tons and 0·5 dwt. as compared with those the year before. Of the ground south of the dyke developed during the year, 3,505 ft. was sampled and was estimated to average only 3·6 dwt. over a 6 ft. stoping width.

Government Gold Mining Areas (Modderfontein).—This company belongs to the Barnato, or Johannesburg Consolidated, group, and was formed in 1910 to acquire mining rights in the Far East Rand to the south of the Modderfonteins and between Brakpan and Geduld. It was the first company formed to acquire leases from the Government on a profit-sharing basis. Milling commenced in October 1914. The plant was doubled last year, the erection of the new plant being completed in October. The capacity is now 120,000 tons per month. The average grade of the ore developed and mined has been low when compared with the figures at the neighbouring mines, and it has not yet been possible to divide any profit, but this position is now steadily improving. The report for 1916 shows that 853,135 tons of ore was raised, and after the removal of 12% by sorting, 744,000 tons was sent to the mill. The yield of gold by amalgamation was 127,219 oz. and by cyanide 110,235 oz., being a total of 237,454 oz., worth £1,008,779, or 21s. 1d. per ton milled. The working cost was £804,091, or 21s. 7d. per ton, leaving a working profit of £204,688, or 5s. 6d. per ton. The average value of the ore disclosed by development during the year was higher than previously, and the reserve shows an increase of 1,265,000 in tonnage and 0·3 dwt. in assay, the figures at December 31 being 4,930,000 tons averaging 7·2 over 75 inches. The consulting engineer, W. L. White, reports the general position to be good and he anticipates steady improvement in profits.

Geduld Proprietary Mines.—This company belongs to the Goerz group, and was formed in 1899 to acquire gold-mining rights in the Far East Rand. Development was commenced in 1904, and milling started in 1908, but owing to water difficulties mining had to be suspended until 1910. The metallurgical plant was extended in 1913, and again just recently. The report for the year 1916 shows that 344,053 tons of ore was raised, and after the rejection of waste, 322,580 tons, averaging 7·6 dwt. per ton, was sent to the mill. The yield of gold was 119,201 oz., worth £504,223, being 31s. 2d. per ton milled. The working cost was £348,593, or 21s. 7d. per ton, leaving a working profit of £155,630, or 9s. 7d. per ton. Out of the profit, £97,000 was distributed as dividend, being at the rate of 10%.



PLAN OF WORKINGS AT MODDERFONTEIN DEEP LEVELS.

Water troubles continued to harass operations, but the difficulties were overcome in November. At the present time about 15 tons of water is raised for every ton of ore. The ore reserve is estimated at 2,150,000 tons, averaging 7·4 dwt. over 60 inches, as compared with 2,100,000 tons, averaging 7·7 dwt. the year before. The current year will show an increase in the tonnage treated, the expected rate being 40,000 tons per month, but probably there will be a decrease in the yield per ton. The chances of further water troubles have also to be taken into consideration.

Modderfontein Deep Levels.—This company belongs to the Goerz group, and was formed in 1899 to acquire gold-mining rights in the Far East Rand, to the south of New Modderfontein. Van Ryn Deep adjoins on the west and Government Gold Mining Areas on the south. Shaft-sinking was started in 1910, and milling at the end of 1914. The report for 1916 shows that the number of stamps was increased from 60 to 70 and the tube-mills from 6 to 7 in May. The ore mined was 518,047 tons, and after the removal of 12% waste, 453,900 tons averaging 9·23 dwt. was sent to the mill. The yield of gold was 202,790 oz. worth £858,084, being an extraction of 37s. 9d. per ton milled. The working cost was £371,121, or 16s. 4d. per ton, leaving a working profit of £486,963, or 21s. 5d. per ton. The dividends absorbed £337,500, being at the rate of 67½%. The yield per ton was 3s. 4d. greater than during 1915. The ore reserve is estimated at 3,320,000 tons averaging 8·4 dwt. over 78 inches, an increase of 650,000 tons, and 0·1 dwt. during the year. The accompanying plan shows the method of development, from twin shafts, adopted at this mine.

Van Ryn Deep.—This company belongs to the Barnato group, and was formed in 1902, as an amalgamation of a company of the same name and the Kleinfontein Deep, to acquire mining claims in the Far East Rand. Milling started in July 1913, and the first dividend was distributed early the next year. The report for 1916 shows that 645,743 tons was raised, and after the rejection of 18·6% waste, 530,070 tons averaging 9⅔ dwt. was sent to the mill. The yield of gold was 246,727 oz. worth £1,048,325, or 39s. 5d. per ton. The working cost was £473,010, or 17s. 9d. per ton, leaving a working profit of £575,314, or 21s. 8d. per ton The shareholders received £478,756, being at the rate of 40%. The policy recently has been to remove more waste by sorting, and to increase the tonnage mined accordingly. The reserve on December 31 was estimated at 2,168,851 tons averaging 8·7 dwt., these figures showing an increase during the year of 124,743 tons and 0·3 dwt. From every point of view the position is sound.

Crown Mines.—This company was formed in 1909 as an amalgamation of the Crown Reef, Crown Deep, Robinson Central Deep, Langlaagte Deep, and other properties in the Central Rand. The control is with the Rand Mines Limited. As has been recorded on many occasions in these columns, the consolidation had for its object the decrease of cost, which would make it possible to treat lower-grade ore at a substantial profit. The expectation with regard to average assay-value has not been confirmed by results, nor has the low level of expected cost been realized. The consequence is that the divisible profits and the rate of dividend have not come up to expectations. The report for the year 1916 shows that 2,483,285 tons of ore was raised, and after the removal of 9% waste, 2,259,700 tons, averaging 6·26 dwt., was sent to the mills. The yield of gold was 694,370 oz. worth £2,887,776, or 25s. 6d. per ton milled. The working cost was £2,072,146, or 18s. 4d. per ton, leaving a profit of £815,630, or 7s. 2d. per ton. The shareholders received £470,053, the rate being 50%. The ore reserve at December 31 was calculated at 11,429,000 tons averaging 5·9 dwt. per ton, as compared with 9,938,000 tons averaging 6¼ dwt. the year before. The alteration in the relative figures for tonnage and content is largely due to the recent reversion to wider stopes.

New Goch.—This company, belonging to the Albu group, was formed in 1887, as the New Goch, to acquire claims on the outcrop in the central Rand between Wolhuter and Nourse. There have been several reconstructions and rearrangements of capital and property. Dividends were paid for 1910, 1911, 1915, and 1916, and in 1915 the balance of debentures outstanding, £112,475, was redeemed. The report for 1916 shows that 404,277 tons of ore was raised, and after the rejection of 10½% waste, 365,000 tons averaging 5 dwt. was sent to the mill. The yield of gold was worth £343,294, or 18s. 9d. per ton milled. In addition, £12,228 was recovered from accumulated slime. The working cost was £248,407, or 13s. 7d. per ton, and the working profit was £112,863. The shareholders received £55,000, being at the rate of 10%. The ore reserve at December 31 was estimated at 404,185 tons averaging 5·3 dwt., together with 48,099 tons partly developed and 72,421 tons in suspense account. These figures are lower by 264,415 tons as compared with the year before. Restriction of development consequent on the diminishing intact area of the mine and the excessive faulting in the bottom level are responsible for this fall. A subsidiary shaft is being sunk for the purpose of mining a faulted portion between the bottom level and the southern boundary, and for working a block of claims recently acquired from City Deep, adjacent to this boundary.

Village Deep.—This company belongs to the Rand Mines group, and was formed in 1898 to acquire deep-level property below the Village Main Reef, which was itself a first deep below the Wemmer, Salisbury, and Jubilee, in the central part of the Rand. The workings are now more than a mile deep. The report for 1916 shows that 723,988 tons of ore was raised, and after the rejection of 13% waste, 626,900 tons averaging 7·4 dwt. per ton was milled. The yield of gold was 222,610 oz., worth £925,752, or 29s. 6d. per ton. The working cost was £659,039, or 21s. per ton, leaving a working profit of £266,713, or 8s. 6d. per ton, out of which £198,875 has been distributed as dividend, being at the rate of 18¾%. The ore reserve at December 31 was calculated at 2,378,000 tons averaging 6·8 dwt., as compared with 2,631,600 tons averaging 6·6 dwt. the year before. There is in addition a large amount of ore under Springfield Township that has not been valued, and owing to certain litigation this ore cannot at present be brought into the reserve.

Meyer & Charlton.—This company belongs to the Albu group. It was formed in 1888 to acquire a small property in the Central Rand, and in 1909 an additional block on the dip was purchased. The mine has yielded as rich ore as any found on the Rand, and still continues to disclose excellent ore in depth. The report for 1916 shows that 183,742 tons was raised and after the rejection of 4% waste, 176,424 tons averaging 12·3 dwt. was sent to the mill. The gold recovered was worth £438,882, or 49s. 7d. per ton. The working cost was £169,193, or 19s. 1d. per ton, leaving a working profit of £283,966, or 30s. 6d. per ton. The shareholders received £200,000, being at the rate of 100%. The profit was the highest on record and showed an increase of £32,344 on 1916. The yield per ton was 4s. 5d. higher. The ore reserve on December 31 was calculated at 512,787 tons averaging 14·5 dwt., of which 312,996 tons averaging 20·5 dwt. was in the Main Reef Leader. A year ago the total reserve was 485,246 tons averaging 12·5 dwt., of which 273,900 tons averaging 18·4 dwt. was in the Leader.

Geldenhuis Deep.—This company belongs to the Rand Mines group, and was formed in 1893 to acquire property on the dip of the Geldenhuis in the eastern part of the central Rand. Excellent dividends were paid from 1897 to 1907, but subsequently a decline in the grade reduced the dividends by one half. In 1909 the remaining portions of the outcrop mine were acquired, as was also the property of the Jumpers Deep. The report for 1916 shows that 788,413 tons of ore was raised, and after the rejection of 12% waste, 696,300 tons averaging 6·36 dwt. was sent to the mill. The yield by amalgamation was 149,430 oz., and by cyanide 63,752 oz., making a total of 213,182 oz., worth £886,728, or 25s. 5d. per ton milled. The working cost was £717,249, or 20s. 7d. per ton, leaving a working profit of £169,478, or 4s. 10d. per ton. The dividends absorbed £146,438, being at the rate of 25%. As compared with the previous year the tonnage milled was 57,500 tons more and the profit £40,877 greater. It is notable that the cost per ton, 20s. 7d., was the lowest in the history of the company. The development during the year has disclosed ore of lower average grade, and the reserve on December 31 was estimated at 1,616,000 tons averaging 5·9 dwt., as compared with 1,826,800 tons averaging 6·1 dwt. the year before. The eastern section is now fully developed, and shaft-sinking for all parts of the mine is nearing completion.

Rose Deep.—This company belongs to the Rand Mines group and was formed in 1894 to acquire property on the dip of the New Primrose in the middle east Rand. In 1909 an amalgamation was effected with the adjoining Glen Deep below the May Consolidated and Glencairn. During the last year or two the developments have not been so good as formerly. The report for 1916 shows that 896,599 tons of ore was raised, and after the rejection of 12½% waste, 782,780 tons, averaging 5¾ dwt. per ton, was sent to the mill. The yield of gold by amalgamation was 139,371 oz., and by cyanide 77,399 oz., making a total of 216,770 oz., worth £900,146, or 22s. 11d. per ton milled. The working cost was £677,225, or 17s. 3d. per ton, leaving a profit of £222,921, or 5s. 8d. per ton. The shareholders received £183,750, being at the rate of 26¼%, as compared with £227,500 and 32½% during 1915. The ore reserve at December 31 was estimated at 3,267,280 tons averaging 5·3 dwt., as compared with 3,605,390 tons averaging 5·2 dwt. the year before. This variation of figures is accounted for by the fact that some blocks of unprofitable ground have been eliminated. The ore developed during the year has been slightly higher than the average grade of the reserve.

City & Suburban.—This company was formed in 1887 under Natal laws to acquire an outcrop property in the central Rand. Latterly the technical control has been with the Central Mining & Investment Corporation. Excellent dividends have been paid regularly, but the mine is now approaching its end. The report for 1916 shows that 363,462 tons of ore was raised, and after the rejection of 10% waste, 324,332 tons averaging 9 dwt. was sent to the mill. The yield of gold was 144,770 oz. worth £601,924, or 36s. 11d. per ton milled, and the working cost was £363,379, or 22s. 3d. per ton, leaving a working profit of £238,544, or 14s. 7d. per ton. The dividends absorbed £170,000, or 12½%. The ore reserve at December 31 was estimated at 602,200 tons averaging 8·8 dwt. In the lower levels the Main Reef has been found to contain ore that will pay to extract. Its utilization will make it possible to maintain the rate of output and so keep the costs down when mining the remaining portions of the higher-grade ore in the Main Reef Leader.

New Heriot.—This company was formed in 1887 under Natal laws to acquire a small property on the outcrop in the central Rand, and the control is in the same hands as the City & Suburban. The technical management is now with the Central Mining & Investment Corporation. The report for 1916 shows that 202,040 tons of ore was raised, and after the rejection of 20% waste, 160,400 tons averaging 8·5 dwt. per ton was sent to the mill. The yield of gold was 67,734 oz. worth £282,033, or 35s. 1d. per ton milled, and the working cost was £180,526, or 22s. 5d. per ton, leaving a working profit of £101,526, or 12s. 8d. per ton. The dividends absorbed £86,250, or 75%. The mine is now practically fully developed. The reserve stood on December 31 at 477,767 tons averaging 7·6 dwt. per ton, figures 58,913 tons and 0·4 dwt. less than the year before. There is a considerable amount of ore still to be reclaimed from the upper levels. About one-third of the ore now milled comes from this source. Howard Warren is the manager.